



**TECHNOLOGY INTEGRATION
INTO SCIENCE COURSE TEACHING -
LEARNING PROCESS:
AN ACTION RESEARCH
M. A. Thesis**

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**TECHNOLOGY INTEGRATION INTO SCIENCE COURSE
TEACHING – LEARNING PROCESS: AN ACTION RESEARCH**

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M.A. THESIS

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ABSTRACT

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The aim of this study is to investigate how technology can be effectively integrated into the science teaching and learning process. Practical action research was employed during the study. The participants consisted of eight seventh-grade students, aged between 13 and 14, selected using a purposeful sampling method. The study was carried out in the first semester of the 2023–2024 academic year. Science lessons were conducted over three weeks utilizing various technological tools, including interactive videos, animations, simulations, and educational games. Data collection instruments included reflection journals, observation field notes and protocols, questionnaires, focus-group interviews, validity committee meeting records, and lesson plans. The collected data were analyzed using both descriptive and inductive thematic analysis.

The findings revealed several challenges encountered, including time constraints, techno-centric distractions, excessive technology integration, and issues with mouse and cursor speed. Strategies such as developing technology integration timelines, selecting and integrating challenging simulation tasks, and aligning tools with instructional objectives were implemented to address these challenges. The findings showed an enhancement in the students' learning experiences with technological tools, fostering understanding, engagement, collaboration, and hands-on learning. The students expressed enthusiasm for these tools, recognizing their effectiveness in promoting comprehension and enjoyment of scientific concepts.

Keywords: Science Education, Science and Technology Course, Technology Integration, Middle School, Action Research.

ÖZET

FEN DERSİNDE ÖĞRETME VE ÖĞRENME SÜRECİNE TEKNOLOJİ ENTERGRASYONU: BİR EYLEM ARAŞTIRMASI

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Bu çalışmanın amacı, teknolojinin fen öğretim ve öğrenme sürecine nasıl etkili bir şekilde entegre edilebileceğini araştırmaktır. Çalışmada uygulamalı eylem araştırması kullanılmıştır. Katılımcılar, amaçlı örnekleme yöntemi kullanılarak seçilen, yaşları 13 ile 14 arasında değişen 8 yedinci sınıf öğrencisinden oluşmaktadır. Çalışma, 2023–2024 akademik yılının birinci döneminde gerçekleştirilmiştir. Fen dersleri, etkileşimli videolar, animasyonlar, simülasyonlar ve eğitsel oyunlar gibi çeşitli teknolojik araçlar kullanarak üç hafta boyunca yürütülmüştür. Veri toplama araçları arasında yansıtma günlükleri, gözlem alan notları ve protokoller, anketler, odak grup görüşmeleri, geçerlik komitesi toplantı kayıtları ve ders planları bulunmaktadır. Toplanan veriler hem betimsel hem de tümevarımsal tematik analiz kullanılarak analiz edilmiştir.

Bulgular, zaman kısıtlamaları, teknoloji odaklı dikkat dağıtıcılar, aşırı teknoloji entegrasyonu ve fare-imleç hızı gibi karşılaşılan zorlukları ortaya koymuştur. Bu zorlukların üstesinden gelebilmek için teknoloji entegrasyon zaman çizelgeleri geliştirmek, zorlu simülasyon görevlerini seçmek ve entegre etmek ve öğretim araçlarını öğretim hedefleriyle uyumlu hale getirmek gibi stratejiler uygulanmıştır. Bulgular, teknolojik araçların kullanımıyla öğrencilerin öğrenme deneyimlerinde bir iyileşme olduğunu, anlama, katılım, işbirliği ve uygulamalı öğrenmeyi teşvik ettiğini göstermiştir. Öğrenciler, bu araçların bilimsel kavramların anlaşılmasını kolaylaştırdığını ve öğrenme sürecinin keyifli hale gelmesini sağladığını belirterek, bu araçlara olan ilgilerini ifade etmişlerdir.

Anahtar Kelimeler: Fen Eğitimi, Fen ve Teknoloji Dersi, Teknoloji Entegrasyonu, Ortaokul, Eylem Araştırması

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Musah NUMAN
Eskişehir, 2024

STATEMENT OF COMPLIANCE WITH ETHICAL PRINCIPLES AND RULES

I hereby truthfully declare that this thesis is an original work prepared by me; that I have behaved in accordance with the scientific ethical principles and rules throughout the stages of preparation, data collection, analysis, and presentation of my work; that I have cited the sources of all the data and information that could be obtained within the scope of this study and included these sources in the references section; and that this study has been scanned for plagiarism with the “scientific plagiarism detection program” used by Anadolu University, and that “it does not have any plagiarism” whatsoever. I also declare that, if a case contrary to my declaration is detected in my work at any time, I hereby express my consent to all the ethical and legal consequences that are involved.

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INDEX OF ABBREVIATIONS

IWB: Interactive Whiteboard

ICT: Information and Communication Technology

2D: 2 Dimensional

3D: 3 Dimensional

VCM: Validity Committee Meeting

TPACK: Technological Pedagogical Content Knowledge

VR: Virtual Reality

CAL: Computer Assisted Learning

ILS: Integrated Learning Systems

1. INTRODUCTION

In the first part of the study, an introduction to the general changes brought about by the emergence of technology in the educational discipline is expounded. Relevant literature on technology integration in science education was reviewed, encompassing topics such as technology integration, technology integration in science education, TPACK competence of teachers, digital technologies used in science education, barriers to technology integration, technology integration framework, and the significance of technology integration in science education. Furthermore, related studies carried out on technology integration around the world and in Türkiye were also examined. Finally, a statement of the problem, purpose of the study, research questions, significance of the study, limitations of the study, and definition of terms were presented.

The advent of technology has profoundly impacted various facets of civilization, ranging from education, agriculture, and communication to healthcare and transportation. Across all spheres of life, the way tasks are performed has undergone significant changes. Despite the drawbacks associated with technology, it can be argued that the overall quality of life has improved. The profound changes and advancements in human life brought about by technology today are incomparable to the traditional way of life. Succinctly, technology has greatly impacted the world, substantially altering how we live, work, communicate, and trade.

The advances brought about by the emergence of technology in various facets of society have also impacted the educational discipline. It has yielded significant benefits in nearly every aspect of organizing and managing educational processes and products. This applied component of technology in the field of education, known as educational technology, holds enormous potential to maximize the output of the educational process for both learners and instructors. To function properly in the ever-changing world brought about by technology, it has become imperative for clientele in the educational discipline, mainly instructors and learners, whether at the elementary, primary, secondary, or upper-secondary level, to be exposed to educational technology (Mangal & Mangal, 2011).

New instructional and educational strategies and approaches have emerged and continue to develop due to technology in the educational field. This has brought forth comprehensive knowledge that incorporates technology, which is currently replacing the prevalent conventional perspective in education. Consequently, technology is being applied in various ways in educational contexts, parallel to advancements in information

and communication technology (Yildirim, 2017). Several applications have been significantly linked to the adoption of technology in education over the years. Terms such as computers, the Internet, instructional software, laptops, and PDAs are frequently used in education to illustrate how technologically up-to-date educational institutions have become as a result of the emergence of technology (Voogt & Knezek, 2008).

One of the changes brought about by technology in the educational field is a revolution in the instructional process. The transition from teacher-centered to student-centered learning is one of these revolutions. In student-centered learning, teachers take on the role of facilitators and give students the responsibility of gathering and interpreting information. This shifts the locus of knowledge acquisition from teachers to students. Furthermore, learning occurs when students take responsibility for their education, create their own course materials, and establish their own learning trajectories (Kang & Keinonen, 2018; Murphy, Eduljee & Croteau, 2021). Consequently, for learners to be ushered into this era, there is a need for teachers, who are one of the most crucial parties in the implementation of the curriculum, to adapt their pedagogical approaches and incorporate the new instructional trends brought about by technology to provide learners with more opportunities and transform them into lifelong learners by integrating these technologies into the instructional process.

The purpose of technology in the educational field is not merely to replace traditional instructional techniques in the instructional setting, but rather to foster innovative approaches in the instructional process (Drent & Meelissen, 2008). Furthermore, when it comes to the integration of technological tools in instruction, it is of great importance to understand that there is no optimal technology to employ; instead, each technological tool or piece of software has its own specific demonstrated intended usage (Luckin et al., 2012). Consequently, it is imperative that instructional methods be modified to fit the technology (Drent & Meelissen, 2008).

It is important to remember that technology is a crucial component of the instructional process that promotes effective learning; it should not just be viewed as an add-on that can be employed at any convenient point in the instructional process. The incorporation of technology goes beyond mastering specific hardware and software; it demands an appreciation of pedagogical principles tailored to technology's use in instruction. The strategies for selecting the desired technologies and the ability to demonstrate how they will be utilized, evaluated, and customized in a way that addresses

instructional problems should all be included in the process of integrating technology into the classroom (Okojie et al., 2006).

It is imperative to always take into account the purpose and strategies that will be employed in the integration of technology into the instructional process to ensure desirable outcomes, and all these should be clearly specified at the planning stage of the instruction. Consequently, instructors, who are the implementors of the curriculum, should be given pedagogy-based training to help them understand the role of learning theory in the design and function of class activities and in the selection and use of technologies in the instructional process (Diaz & Bontenbal, 2000).

The integration of technological tools in the classroom requires the administration of a broad range of software and hardware sources, as well as various teaching models and task types. Teachers must possess a high degree of professionalism and teaching abilities for this integration (Angeli & Valanides, 2004; Webb, 2002).

The positive impact of integrating technology into educational disciplines has been evident across various curricula. This is particularly true for science education, a critical component of K–12 education. The nature of science teaching and learning necessitates modern and technological instructional materials for effective implementation. Numerous studies have demonstrated that integrating technology into science education yields significant positive results. According to Linn (2003), the Internet, word processors, presentation software, and spreadsheets, among many others, are some of the new technology tools that may be used to enhance the learning of science. The integration of these technological tools in science content, if done effectively, necessitates the use of appropriate pedagogy, takes advantage of the special features of technology, increases the accessibility of science, and sets the stage for the development of students' understanding of the relationship between technology and science (Lederman, 2000).

Apart from the other effects that technology has on learning, it also ultimately makes the entire instructional process fun (Baydaş & Göktas, 2016). Additionally, technology supports teaching and learning, as well as information resources, making a significant contribution by promoting more effective learning and offering assistance and complementary support for both teachers and students (Jamieson-Proctor et al., 2013). Furthermore, technology integration in the classroom promotes knowledge development in a more flexible context and offers an expanded learning environment (Sang et al., 2010).

The integration of technological tools into the classroom has provided teachers and students with more options for information and communication, thanks to the increased use of school desktop and laptop computers, as well as handheld devices. According to Salpeter (2003), the integration of technology into the instructional process supports idea exchange, cooperation, and the use of productivity techniques and instruments. It has also been found to promote 21st-century skills and improve learning among students. Students' self-direction and higher-order thinking can be encouraged through technology (Learning for the 21st Century, 2003).

Over time, there have been substantial changes in the ways that science is taught using technology. Science education has changed dramatically as a result of technology, from the first calculators and overhead projectors to the current applications of virtual reality, artificial intelligence, and internet resources. With the many technological tools and resources available to them today, educators may improve the way they teach science. Teachers may provide their students more dynamic and interesting learning experiences by integrating these technologies into their classes. These resources support students' critical thinking, problem-solving abilities, and teamwork while facilitating the investigation and comprehension of scientific concepts (Yilmaz, 2023).

Harris and Rooks (2010) opine that students are employing technology tools akin to those used by practicing scientists. Additionally, it has been discovered that technology is rather important in programs designed to improve science teaching across the board in the K–12 curriculum through inquiry learning. All these initiatives highlighted educators employing student-centered, inquiry-based methods in their classrooms, ensuring the inclusion of all students, irrespective of their abilities. Most importantly, all of the programs utilized Web 2.0 tools, including blogs, webcasting, podcasting, and live video meetings (Owston, 2009).

Previous studies have elucidated the numerous benefits provided by integrating technological tools into the science teaching and learning process. These benefits include enhanced critical thinking skills, improved problem-solving abilities, better comprehension of scientific concepts, and more enjoyable science teaching and learning (Yilmaz, 2023; Chander & Arora, 2021; and Darwin, Rusdin, Mukminatien, Suryati, Laksmi, & Marzuki, 2023). However, the ineffective integration of technology in the instructional process can lead to numerous problems. Consequently, science educators have made, and continue to make, significant efforts to investigate how to effectively

integrate technological tools into science education. This area of research remains ongoing, paralleling the continuous advancements in technology. Action research has proven particularly beneficial in this domain, as it allows science instructors to be fully present in the research setting, experiencing and practicing the effective integration of digital technologies into science education. This thesis focuses on a science teacher's initiative to explore how to effectively integrate various technological tools into his science course through action research.

1.1. Literature Review

In this literature review, the essential elements of integrating technology into science education were reviewed. The key concept of technology integration and the rationale for its implementation in the classroom were also highlighted. To shed light on how to effectively integrate technology into science instruction, a number of related factors were examined, including the significance of technology integration in science education and the need for science teachers to possess strong TPACK competence. In addition, the digital technologies integrated into science instruction, barriers to technology integration, and the proposed technology integration framework (TIF) by Saglam and Demir (2012) were all examined. Some related studies on the integration of technology in science education from Türkiye and abroad were also reviewed.

1.1.1. Technology integration in education

Early in the 20th century, schools started using films, photographs, and slides, which marked the inception of the meaningful integration of technology into science instruction (Reiser & Dempsey, 2007). Then came the introduction of projectors, sound films, radio, television, video recorders, computers, and the Internet, respectively. Students were able to confront, examine, and reconstruct their own beliefs about science with the aid of computers.

In recent years, educators around the world have understood that proficient and effective use of technology is not only necessary and achievable, but it may also maximize children's learning potential as digital natives (Weir, 2020). As society develops, good technology integration in the classroom may become the norm. In order to successfully incorporate technology for pupils, educators must be ready, equipped, and brave. There is a need for students to be educated with technology in every aspect of their lives in an

ever-changing, technologically reliant society in order to function effectively in this type of environment and improve their proficiency in utilizing digital technologies. Teachers, who carry out the curriculum, bear some responsibility for providing this type of instruction. Hence, in order to assist students in becoming accustomed to and knowledgeable about digital technologies, it becomes crucial for teachers to incorporate technology into their instruction. The teachers themselves must be tech-savvy enough to accomplish this, which is the situation's other requirement. In essence, incorporating technology into the learning process is favourable for both teachers and students.

Technology integration is the effort made by teachers to include technology into the curriculum in educational institutions such as schools or colleges so that students can use their computer and technology abilities in the learning and problem-solving processes (Pisapa, 1994). Utilizing learning technologies to apply, enhance, support, and develop skills is known as technology integration in education. The successful integration of technology takes place when using technology becomes prevalent, transparent, and supports curriculum objectives (Staff, 2008). Effective technology integration goes beyond simply bringing in computers and related technologies to the classroom in order to generate new kinds of learning experiences. When technologies are integrated into instruction, they constitute an essential component of the teaching and learning process, since the word "integrate" refers to the combination of two or more elements to create a whole (Cennamo, Ross, & Ertmer, 2010).

To successfully integrate technology into the classroom, both teachers and students need guidance and assistance (Huffman, 2016). For teachers to integrate technology into their instruction, they must feel comfortable using it in instructional activities and be aware that it will improve the meaningful learning of their students (Keengwe et al., 2008). According to Dwyer, Ringstaff, and Sandholtz (1991), integrating technology into instruction necessitates altering a variety of instructional elements, such as the resources used, the teacher's and students' responsibilities, as well as the nature of the instructional activities themselves.

Cennamo, Ross, and Ertmer (2010) claim that teachers frequently neglect the use of technology in the inquiry process in science because of the emphasis on hands-on learning. However, there are numerous significant ways that technology may support scientific inquiry in the classroom. For instance, it can provide students with access to places and insights into scientific procedures that they would not otherwise have. Digital

video, photography, virtual labs, and live interactive clips are just examples of the technologies that can take students to a completely different world. Additionally, it is capable of giving them perspective and motivating them to keep learning by piquing their curiosity.

1.1.2. Technology integration in science education

Technology must be incorporated into education today because it can change and advance learning settings for all students. This is why technological tools are an essential and practical way to transform education because of their distinctive capacity to engage and foster curiosity among students (Ly-Hoang, Sun, & Ulanoff, 2022). Students' participation in the teaching and learning process is frequently provided in a classroom that successfully integrates technology into the teaching and learning process. Making the students the focus of the instruction is a common philosophy that encourages technology integration in the classroom. Several practitioners who integrate technology into the teaching and learning process have observed this and have spoken favourably of the positive impact it has on raising student engagement and fostering meaningful learning (Liu et al., 2022).

According to Kermani and Aldemir (2015), integrating technology into science classes enhances students' interest in the subject. This is because understanding science can stimulate students' interest and enjoyment in exploring their environment and establish the foundation for lifelong learning (NSTA, 2014; NSTA, 2016). The emergence of technology has paved the way for the advent of numerous technological devices to be integrated into the instructional process. The most popular among these technological devices are simulations, augmented realities, virtual labs, and online resources. Unquestionably, one of the most significant aspects of these tools is their ability to incite and maintain students' interest in the instructional process. According to Doyan, Makhrus, and Zamrizal (2021) and Goumas, Symeonidis, & Salonidis (2016), the incorporation of contemporary technology into scientific education offers educators and students creative instruments to investigate, test, and understand the complexities of the natural world. Furthermore, these technologies have the power to revolutionize science education by encouraging inquiry, critical thinking, and a better appreciation of the scientific ideas that underpin our understanding of reality (Kim, Hannafin, & Bryan, 2007; Mishra, 2017).

Science subject knowledge instruction and the development of students' science process skills can both be improved through the use of technology, but doing so necessitates a clear grasp of the learning objectives and the role that technology will play in accomplishing those objectives (Davies, Sprague, & New, 2008). It is undeniably true that technology is a vital instrument for science instruction. Technology integration as a whole is based on the idea that it should support instruction rather than take its place. In this situation, technology serves as a means to an end, and it is not the end in itself. Learning is not improved by the simple introduction of technology in the classroom. Technology enhances science instruction, according to Davies, Sprague, and New (2008), when the learning activity is in line with the course's learning objectives, is well-structured, and when the tools and materials that will be used are properly handled. This implies that the planning that comes before integrating technologies into instruction is far more crucial than the actual technological tools. If these plans are not correctly developed, the pupils will be left perplexed in an impromptu class involving technological devices. Kozma and Croninger (1992), Fisher, Dwyer, and Yocam (1996), as well as Lemke (2005), agreed with this assertion and stated that in order for the desired learning to take place, the technology must be used effectively and with a purpose to support the intended learning objectives.

Science instruction can be made more effective and efficient by using technology, but only when it is appropriately integrated. When a science teacher has a firm grasp of the true nature of science (i.e., both subject knowledge and process skills), has acquired a working understanding of the function and utility of technology, and matches the usage of technology with the course's learning objectives, technology integration is done well (Davies, Sprague, & New, 2008).

In a laboratory setting, effective science instruction can be enhanced by technology, but this requires a well-structured learning activity and the appropriate use of materials and equipment to enable students to successfully complete the intended tasks (Davies, Sprague, & New, 2008). It typically comes down to the teacher's ability to plan the activity well and whether technology will be successfully and efficiently integrated into a science classroom. The lab activity needs to be planned and structured by the teacher, taking into account the physical space constraints, the tools and supplies required, the time allotted, and the students' need for direction while they investigate the subject. And although there is no assurance that using technology will result in students' learning, effective

technology integration can raise the likelihood of students learning in the science classroom (Davies, Sprague, & New, 2008).

It has been observed that technology-enhanced classes with technological tools for phenomena that are difficult to study in a classroom might be more effective than traditional science lessons. Technology can aid in putting scientific knowledge into practice and engaging students in science (Rehmat & Bailey, 2014). Additionally, by emulating what scientists accomplish with the use of technology, students can frequently actively interact with the natural world.

Although it has lately been observed that technology is employed in inquiry-based science classes outside of the traditional rote learning framework, technology is still mostly used for practice and application. According to Kim et al. (2007), a fundamental strategy for developing people who are literate in both science and technology is the use of technology by teachers to teach and conduct science as well as by students to learn science and conduct research. Hence, it is important for science teachers to develop their Technological Pedagogical Content Knowledge (TPACK).

1.1.3. TPACK competence of teachers

Shulman (1986) introduced a comprehensive framework for understanding teachers' knowledge necessary for effective teaching. He identified two primary domains: content knowledge and pedagogical knowledge. Content knowledge encompasses the depth and organization of information within the teacher's mind, including subject-specific theories, concepts, ideas, evidence, proofs, and methodologies (Shulman, 1986). In contrast, pedagogical knowledge pertains to understanding how to effectively convey and represent subject matter to facilitate student comprehension. However, Shulman argued that these domains alone are insufficient for effective teaching. He introduced Pedagogical Content Knowledge (PCK) as a critical intersection of content and pedagogical knowledge. PCK involves an awareness of what makes learning particular topics easy or difficult, considering the various preconceptions and misconceptions students bring based on their diverse backgrounds and ages. Teachers must be equipped with strategies to address these misconceptions, as learners typically do not approach subjects as blank slates (Shulman, 1986).

A theoretical framework known as Technological Pedagogical Content Knowledge (TPACK) analyses the interaction of technology, pedagogy, and content knowledge in

teaching and learning (Koehler & Mishra, 2008). The framework places a strong emphasis on the significance of comprehending how technology might enhance the teaching and learning of certain subjects in specific circumstances. According to the TPACK framework, instructors must possess a thorough understanding of the subject matter and instructional techniques, as well as the technical know-how required to employ technology in the classroom (Mishra & Koehler, 2006). While TPACK is an extension of Shulman's PCK, focusing on the integration of technology into teaching, Shulman's original work lays the foundational idea that effective teaching requires an understanding of both the subject matter and the most effective ways to teach that subject to students.

For teachers to successfully create and implement technologically enhanced lessons that are in line with their students' learning needs and the curriculum, they must possess TPACK (Koehler & Mishra, 2009). When instructors are TPACK competent, they may utilize technology to help students learn their lessons in an engaging manner. They can also provide students with opportunities to apply their knowledge in real-world situations (Mishra & Koehler, 2006). Additionally, TPACK competency empowers instructors to remain abreast of the most recent technological developments and apply them to improve their instruction in ways that are consistent with the most recent findings on effective instructional processes (Koehler & Mishra, 2008).

Teachers require TPACK because it enables them to successfully use technology in their lessons to improve student learning (Koehler & Mishra, 2009). TPACK enables instructors to utilize technology to its fullest potential in order to enhance and assist the teaching of science material as well as students' participation in scientific inquiry and problem-solving (Niess, 2005). Additionally, TPACK aids teachers in comprehending how technology may support various teaching pedagogies and learning philosophies, which is crucial in the science classroom because students may have a variety of learning needs (Ertmer & Ottenbreit-Leftwich, 2010).

Niess (2005) further asserted that there is a need for science instructors to also gain a comprehensive understanding of their subject matter with respect to technology and what it means to instruct with technology in order for it to become an important component or instrument for learning. Furthermore, there is a need for science teachers to develop their TPACK competence, as it can assist them in improving their own professional growth and development in addition to improving student learning outcomes. Teachers who demonstrated high levels of TPACK competency, according to

research by Schmidt et al. (2009), were more certain and competent in integrating technology into their instructional process. This in turn enhanced job satisfaction and motivated teachers to keep raising the bar on their instruction.

Teachers who are TPACK-competent can also adjust to the rapidly changing technological world. Teachers must be able to keep up with the various tools and applications that emerge as technology develops. Teachers with TPACK competency, according to Koehler and Mishra (2009), are able to learn and adjust to new technologies, incorporate them into their teaching methods, and assess their efficacy.

1.1.4. Digital technologies used in science education

Digital technologies alter science education by transforming the learning environment and giving students the opportunity to build their own knowledge. It transcends the "direct instruction" or "lecture" method that many underachieving students find to be so difficult. Instead, there are numerous methods to employ technology to support students' active learning. As tools for discovery-based classrooms, many digital technologies and related applications can provide students with access to data, simulation experiences, and the opportunity to build models of basic scientific processes. Digital technologies can be useful tools for inquiry, conducting investigations, performing analyses, modeling scenarios, and communication. Digital technologies are most effective when they provide you with the power to take charge, deal with issues, conduct cooperative research, and observe occurrences that would otherwise be invisible (Adams & Hamm, 2014).

According to Jasper (2012), teachers must integrate technology into their classrooms and create interactive learning environments to keep students engaged. A teacher who wishes to integrate technology into the classroom should strive to inspire students by exposing them to the most cutting-edge software and digital environments. Schools should work to enhance classrooms using technology. There are many technological devices that can be used to enhance students' learning in the science classroom. The following is a list of some technological tools that can be used to enhance science lesson:

- Virtual lab
- Virtual reality
- Tutorial applications

- Simulations and modelling
- Data logging and graphing
- Interactive whiteboard
- Digital videos
- Digital games
- Smartphones and tablet computers

1.1.4.1. *Virtual lab*

Virtual labs have been defined in various ways. A virtual lab, in accordance with Aljuhani et al. (2018), is a computer-based simulation of a lab setting that enables students to carry out experiments and gather data in a digital format. Virtual labs, in the words of Scheckler (2003), are interactive learning environments that digitally reproduce in-person laboratory activities through the use of simulations, computer technologies, and other instructional technologies. According to Zhao (2015), a virtual lab is a play space for experimentation where users can design and carry out simulated experiments. Through the use of a virtual lab, students are given the opportunity to gather data from the real world with the help of the internet. Students can conduct virtual experiments whenever and wherever they like, thanks to remote computer access to lab equipment. With the use of this technology, laboratory instruction may be much more adaptable, and students are also introduced to the new paradigm of remote experimentation. This technology could also be highly beneficial during lockdown periods, as experienced worldwide during the COVID-19 pandemic.

Roblyer and Hughes (2019) claim that virtual laboratories let students conduct experiments in a virtual setting and that they can be utilized independently or in conjunction with other real-world hands-on labs. According to Brinson (2015), interactive presentations, instructional films, animation and simulation tools, and simulation software may all be used in designing virtual labs. The objective of this instructional design, from a theoretical standpoint, is to create a positive learning environment where students can engage with online learning materials whenever they want, wherever they are, and at their own pace. Students can run online experiments multiple times in the virtual lab at a lower cost and in a more secure environment than in actual labs.

Virtual labs are gaining popularity as a visual tool that could benefit both students and instructors by streamlining time-consuming procedures. According to Diwakar et al.

(2012), virtual labs provide a variety of analyses through a variety of components, including user-interactive animations, simulations, remote activation of actual laboratory equipment, and haptic devices. In a virtual lab, graphical animations can more effectively convey the feel and imagery of a genuine laboratory. Animations offer a better diagrammatic comprehension of the concepts of an experiment in a way that cannot be easily communicated using text-based or passive visuals in a traditional lab. The goal of using visualization techniques in virtual labs is to make learning science enjoyable for the student by allowing them to freely interact with the virtual environment (Huang, 2003). Students may experience issues in a traditional lab system, such as restricted access to laboratory facilities, equipment shortages, and insufficient technical support, which may impede their interest in learning science. Virtual laboratories are crucial in overcoming the lack of lab facilities and designing personalized learning experiences at a minimal cost, boosting the likelihood of self-organized learning strategies (Mitra, 2005).

1.1.4.2. *Virtual reality*

Virtual reality (VR), according to Psotka, Davison, and Bernatchez (n.d.), is a technology that uses specialized hardware and sophisticated software to construct an artificial environment that gives users a profound sensation of immersion and presence. The mental belief or sensation of being present, enveloped in space, and equipped to engage with all available items in the virtual environment is referred to as immersion. In contrast, presence refers to the sense of actually existing in the virtual reality environment, being totally immersed in the environment, and being able to interact with other items that are there. This definition stresses the key elements of VR and underlines the capability of the technology to immerse people in a fully realized, computer-generated environment.

Pantelidis and Vinciguerra (2010) provided a succinct description of VR as a computer-generated environment that is highly interactive and can either be text-based or graphics-based. This description recognizes that VR can have various forms, some of which rely on graphical representations and others that use text-based user interfaces. The authors also pointed out that some forms of VR, including collaborative virtual environments, can incorporate both text and graphics to produce a more participatory and immersive experience in 2D or 3D virtual environments.

According to Hennessy et al. (2007), students have the exceptional chance to encounter and investigate a wide variety of places, objects, and phenomena through the use of virtual reality. Students have the ability to view and control inaccessible variables, processes, and objects. Additionally, by providing visual representations of physical processes, these digital technologies might enable students to establish exploratory connections between scientific theory and empirical facts.

1.1.4.3. *Tutorial applications*

One of the earliest applications of technology in the teaching and learning process was computer-assisted learning (CAL). A subject-specific program called CAL allowed students to review fundamental concepts or, at a slightly more advanced level, gave them tutorial-style instruction on the content being studied. The creation of these applications ultimately resulted in the development of Integrated Learning Systems (ILS); programs that offer students personalized education in the form of an intelligent tutorial system that gives performance feedback practically instantly. The platforms also maintain performance records for access by teachers (Bennett, 2004).

ILS are systems, according to Muijs and Reynolds (2006), that consist of content, a system for logging and responding to individual replies, and a management system. They function essentially as drill-and-practice programs, with children seated in front of the computer responding to questions that appear on the screen and receiving rapid feedback. Additionally, the system keeps track of every response a student provides, enabling it to generate a report on the student's progress. ILS has the benefit of letting students skip a question if they seem to understand it rather than having to respond to a ton of other questions on the same subject. This can make students feel less bored, yet students still appear to be motivated by using computers in general.

1.1.4.4. *Simulations and modelling*

Simulations and modeling are two of the indispensable technological devices integrated into the science teaching and learning process. The technology tools used in simulations and modeling are somewhat distinct but related. Users explore a model that is integrated into a computer program during simulations. In the science teaching and learning process, this enables students to obtain experience with phenomena that, for instance, may be dangerous or whose timeline does not easily allow for straightforward

replication in a school science laboratory. On the other hand, modeling software, as its name suggests, enables users to create their own models. This is mostly accomplished by eliminating the monotony of lengthy and repetitive calculations. Modeling software can be used to manipulate specific types of data in the most basic sense. This enables students, for instance, to investigate correlations between variables in science lessons. At a more advanced level, content-free modeling software enables students and teachers to create and experiment with their own models using basic programming languages (Bennett, 2004).

Simulation, as noted by Osborne and Hennessey (2003), provides idealized, dynamic, and visual representations of physical events and experiments that would be difficult, expensive, or sometimes unsafe to do in a classroom laboratory. Additionally, it liberates students from time-consuming manual tasks, accelerating the completion of tasks and allowing teachers and students to concentrate on important topics without being distracted. The utilization of simulations has the potential to assist in science instruction by motivating students to inquire about and research exploratory subjects and producing less haphazard data (Baggott & Nichol, 1998).

Simulations have been created to provide students with access to phenomena or laboratory experiences that are otherwise not feasible or are only partially feasible in traditional science classrooms. These simulations help develop procedural skills such as operating scientific equipment (e.g., microscopes, Bunsen burners, or multimeters) and performing standard lab procedures. Additionally, simulations serve as a supplement to real-world experiments that cannot be conducted in typical science classrooms (Stinken-Rösner, 2020).

The beneficial effects of computer simulations in science education have been the subject of several studies. Interactive simulations may be used in the classroom to help science students develop a variety of abilities, including observing, measuring, predicting, manipulating variables, formulating hypotheses, and evaluating data (Droui & El Hajjami, 2014; Mahdi & Laafou, Mohamed R., 2018). In addition to improving classroom engagement and interest, it enables students to actively develop metacognition and to reflect on their learning (Droui & El Hajjami, 2014). Additionally, it increases student engagement and enthusiasm in the classroom (Martinez-Jimenez et al., 2003; Stéphane & Ze, 2018). Furthermore, according to Jemaa and Boilevin (2016), it aids students in

overcoming learning challenges and addresses the issue of common misunderstandings to some extent.

1.1.4.5. *Interactive whiteboard*

The interactive whiteboard (IWB) is a type of Information and Communication Technology (ICT) tool that is increasingly employed in classroom settings. An interactive whiteboard is a touch-sensitive board that enables instructors and students to actively engage in activities that are projected onto it through a computer-connected data projector. A computer, a data projector, and a touch-sensitive whiteboard make up an interactive whiteboard's three major components (Muijs and Reynolds, 2006). Chin (2004) added special software as the fourth component. The system's computer enables usage of the Internet, digital television, and other technologies, including sound systems, as well as access to other forms of digital material (Watch, 2001, p. 26 - cited in Anagün & Duban, 2016). According to Kennwell and Higgins (2007), IWB combine a blackboard, computer, overhead projector, CD player, video player, or flip chart. As a result, all types of media can be used on only one device. By facilitating greater access to multimedia materials and multimodal concept representations, the IWB has the potential to enhance how students engage with learning and instruction (Murcia, 2008).

There are numerous software and hardware options for smartboards available today. This offers a benefit for schools using smart boards. As a result, schools can select the brand that best suits them and their educational endeavours (Betcher & Lee, 2009). The notable features of the software on smart boards include the ability to drag items on the screen, including various virtual pens, the capacity to enlarge and focus on a particular location on the page, and the presence of a sizable, readily available collection of images and backgrounds. In addition to this, interactive tools of various kinds can be found on smart boards (Betcher & Lee, 2009).

IWB has numerous advantages in the instructional process. It may be used to engage with students' regular digital experiences, particularly with regard to the availability and utilization of information. When used properly, IWB technology can improve or support instructional possibilities in contemporary classrooms (Higgins et al., 2007; Murcia, 2008; Betcher and Lee, 2009; cited in Murcia and Sheffield, 2010). Instructors and pupils may also engage with all of the functions of a personal computer thanks to the technology embedded in the large touch-sensitive surface of the interactive

whiteboard. When utilized effectively, the features of an IWB and its supporting software can maximize student interaction with the science learning material and the teacher (Murcia, 2008; Betcher and Lee, 2009, cited in Murcia and Sheffield, 2010).

On the significance and benefits of the IWB, Muijs and Reynolds (2006) opined that, compared to traditional blackboards, whiteboards, and simple projector systems, whiteboards have a number of distinct benefits. The benefits of digital whiteboards over traditional blackboards and whiteboards are primarily the better presentation options and the easy access to educational resources that can reduce teachers' workloads. Teachers can create interactive multimedia presentations on interactive whiteboards or use pre-made packages that are available for the interactive whiteboard. This is especially helpful when demonstrating processes and change because students may now be "shown" rather than "told" what is happening. The interactive whiteboard's main advantage over projection techniques including a computer and projector is its increased interactivity. Students can interact directly with exercises, etc., on the whiteboard thanks to the touch screen.

1.1.4.6. *Digital videos*

Digital videos are among the most crucial technological tools that are increasingly integrated into the instructional process. This piece of technology is capable of addressing the learning needs of almost all students, as it provides audio-visual resources for them. Digital video is a form of video recording system that uses a digital video signal rather than an analog one to operate. Digital videos can be modified using widely accessible technology and software and copied numerous times with essentially no quality loss. Digital video is also utilized for mobile phones, video conferencing systems, and the dissemination of material via the Internet, in addition to digital television (including HDTV) (New World Encyclopaedia, 2023).

Digital videos, which now have the ability to stream, have made it possible for educational networks to be created and developed, as well as for the use of digital videos to rise as the internet environment has developed. Digital videos are becoming more beneficial for both entertainment and education because of the emergence of publicly accessible video websites like YouTube (Bijmens et al., 2006).

Digital videos can be viewed or edited on computers or smart mobile devices, according to Anagün and Duban (2016), although software is needed to do so. Today's

technology, however, makes it possible to view and edit digital videos for free with the help of special Web2.0 tools. Digital videos can thus be quickly set up for use in learning environments and training scenarios, and they can be easily exhibited to students in a classroom.

There are numerous resources available today that can be used in the field of education and training when using digital videos in a web environment, and the number of these resources is constantly growing. The usage of these videos by teachers is not limited to online viewing; they may also be downloaded to a computer and used offline or outside of the web environment, as well as in a variety of different ways, such as incorporating them with other videos (Robin & Tillman, 2010). When digital videos are used in the classroom, students are more likely to be motivated than when traditional teaching techniques are used because they are more engaged and excited about the material.

Digital videos can also be used in science education to teach students about living things that are not present in the classroom, to demonstrate catastrophic events like earthquakes and floods, and to explain the structure of the world so that the material is more directly relevant to their lives (Anagün and Duban, 2016). The important aspects of integrating digital videos into the lessons are considering copyright issues, giving references to the sources, and considering students' levels of development, cultural considerations, and the aims of the courses.

1.1.4.7. *Digital games*

The term game has been defined in several ways and via various attempts. Koster (2005) described a game as a system where participants participate in a conceptual task with guidelines, responses, and interaction that leads to a measurable result and frequently elicits an emotional response. This definition includes, according to Kapp (2012), the following components: a system, participants, conceptual task, guidelines, interactions, response, a measurable result, and an emotional response. These dissimilar components work together to create an event that is more substantial than the sum of its parts. The instant feedback and continual engagement linked to the game's challenge—which is set by the guidelines—make the participant feel engaged in the experience. Together, these components of the system generate an emotional reaction that produces a measurable result inside a conceptual representation of a more expansive system.

It is not a new idea to utilize games in a learning environment, but gamification—the idea of applying gaming principles to education—has just recently gained popularity (Orhan Göksün and Gürsoy, 2019). Gamification, according to Kapp (2012), is the process of enticing people to interact, take action, encourage learning, and solve challenges via the utilization of aesthetics, game mechanics, and game thinking. Gamification in education is a technique that allows students to play imaginative games in a learning environment without compromising the curriculum's scientific foundation (Nolan & McBride, 2014, cited in Kiryakova, Angelova, and Yordanova, 2014).

1.1.4.8. *Smartphones and tablet computers*

Smartphones, albeit not precisely defined, are mobile phones with applications and Internet connectivity, according to a description provided by PC Magazine (2014a). Modern smartphones, however, also have the ability to install paid and unpaid programs, including those for sending emails, reading websites, taking pictures and videos, and playing MP3s and videos. Tablet computers, on the other hand, are portable computers with a single display that typically employ touch as the input method (PC Magazine, 2014b).

The majority of smartphones and tablets use mobile operating systems that resemble desktop ones. The ability to install programs (applications) on smartphones and tablet computers, much like PCs, is one of the most significant benefits of having an operating system. Different operating systems, such as Android, iOS, and Windows Mobile, can be found on smartphones and tablets. It is possible to take advantage of smartphones and tablets in the same manner because they can operate with the same operating systems (Anagün and Duban, 2016).

Approximately 96.8% of people worldwide had access to mobile devices in 2019; in certain developed countries, this percentage was 100% (Sarker et al., 2019 cited in Wang, Hsieh, & Kung (2023). Smartphones have swiftly penetrated the fields of communication and education, among others, thanks to their multifaceted purposes, and for many people, they have become an indispensable element of daily life (Haug, Castro, Kwon, Filler, Kowatsch, & Schaub (2015). According to Looi et al. (2016) and Yi et al. (2016), smartphones are viewed as practical, simple-to-use gadgets that encourage engagement and multitasking and support both formal and informal learning.

Studies on the effects of smartphones and tablets on learning and academic achievement have been investigated. Students' achievement considerably improves when they use mobile learning devices, such as smartphones, during learning time, as Norris, Hossain, and Soloway (2011) showed in their study. This is due to the fact that, as they have the gadget close at hand, their time on task completion increases. Smartphones, according to Valk, Rashid, and Elder (2010), have helped to lessen the inherent rigidity of traditional classroom instruction and have made learning more flexible and simpler. For instance, a smartphone enables students to access instructional resources at any time and from any location, and doing so is extremely cost-effective because smartphones already provide this feature (Darko-Adjei, 2019).

Some results that emerged from studies looking at the relationship between smartphone use and student outcomes and academic achievement are frequently ambiguous. According to Junco (2012), university students' use of smartphones and academic success are negatively correlated. According to Foen Ng et al. (2017), college students who use smartphones for academic purposes had poorer cumulative grade point averages. According to meta-analysis findings, using a mobile phone occasionally affects one's ability to learn (Kates et al., 2018). The controversial findings regarding smart phone usage in education indicate that integrating this technology into the teaching and learning process of educational programmes requires special attention.

1.1.4.9. *Web 2.0 and Web 3.0*

McLoughlin and Lee (2007) defined Web 2.0 as a supplementary online platform that facilitates content development, group collaboration, and information exchange between users. In other words, they are second-generation online apps that are effectively incorporated into educational systems with the goal of facilitating communication, sharing knowledge, and teamwork (Faboya & Adam, 2017). On the other side, web 2.0 is defined by Çelebi and Satırlı (2021) as activities that make it easier for people to share information and collaborate online, both individually and in groups. These are internet-based technologies that are accessible from any location (Avcı & Atik, 2020).

Web 2.0 applications are described by Korucu and Çakır (2015) as dynamic web technologies that offer chances to satisfy current demands. Applications include social networking sites, wikis, weblogs, podcasts, video-sharing platforms, instant messaging apps, virtual museums, Google Earth, and news sources (RSS). Web 2.0 tools that can be

used in educational settings can be categorized as follows: concept teaching tools, virtual reality tools, language education tools, classroom management tools, coding tools, blog preparation tools, photo and video preparation tools, game tools, alternative assessment tools, note taking, animation preparation tools, posters, journaling, story tools, cartoon tools, distance learning and virtual classroom, coding, and other tools (Çelik, 2021; Tatlı, 2017; Yıldırım, 2020).

The World Wide Web's principles are carried over by Web 3.0 technologies, also known as the semantic web, which provide the Web "meaning" so that machines can comprehend the meaning of data (Berners-Lee, Hendler, & Lassila, 2001). Consequently, the participatory world that Web 2.0 offers is distinct to individuals with the advent of Web 3.0 technology. By sifting through a large amount of untrue data to meet user demands during internet searches, Web 3.0 makes it easier for consumers to find relevant information (Chisega-Negrilă, 2013). Thus, the goal of Web 3.0 tools is to offer a semantic web environment so that people may easily and whenever they need to get the information they require (Miranda et al., 2014). With the advent of Web 3.0, educators now have access to additional tools and resources that can improve instruction in these areas. Web 3.0 offers a number of benefits, such as more individualized instruction, more motivation and engagement, massive data access, ease of cooperation and communication, and creative evaluation techniques.

Several studies have emphasized the major benefits of Web 3.0 in science education. According to Balakrishnan (2018), Chassignol et al. (2018), and Peirce et al. (2008), Web 3.0 has the potential to give students more individualized learning experiences. Web 3.0 has the potential to enhance scientific education by boosting student enthusiasm and engagement (Hussain et al., 2018; Sinatra et al., 2015). This is so that they can provide teachers new tools to make learning more dynamic and interesting, such as augmented reality experiences and virtual simulations. Furthermore, students can stay motivated and involved in their learning by receiving timely feedback from Web 3.0 technologies on their progress in understanding scientific concepts (Hussain et al., 2018). Also, they possess the capacity to retrieve and evaluate enormous volumes of data (Jordan & Mitchell, 2015; Sarker, 2021). To pinpoint areas of strength and weakness and provide focused interventions, educators can utilize the data on student performance that these technologies can assist in gathering and analyzing. Additionally, they can promote cooperation and communication (Lal, 2011; Miranda et al., 2014; Pattnayak & Pattnaik,

2016). For the purpose of evaluating student learning, Web 3.0 can provide educators new resources and approaches (Ali & Abdel-Haq, 2021; Zawacki-Richter et al., 2019). Real-time performance monitoring and adaptive testing are two examples of more creative and successful evaluation techniques that may be created with the use of these technologies.

1.1.5. Technology integration in curriculum

The use of technology in the classroom is not a recent development in education. Historically, computers were primarily utilized to teach fundamental skills through repetitive "drill and practice" software. While these programs still have a role in focusing on basic skills, educators are increasingly recognizing the broader potential of computers to enhance student learning. The modern classroom is evolving beyond the simple use of computers for teaching basic skills. (Frei, Gammill, & Irons, 2007).

While the widespread adoption of technological tools in educational processes surged in the 1980s with the introduction of computers to facilitate and conduct educational activities in schools (Fries & Monahan, 1998), examples from this period demonstrated that these tools were often confined to classroom settings or not utilized as originally intended. Instances where successful integration occurred have also been highlighted (Bauer & Kenton, 2005; Turan, Yılmaz, Durdu, & Göktaş, 2016). However, technology integration in education entails more than just the presence of technological tools. It fundamentally involves incorporating these tools into the curriculum to make significant improvements in learner performance and academic achievement (Shi & Bichelmeyer, 2007).

Technology integration in education refers to the systematic and efficient utilization of technological tools in designing, implementing, and managing the teaching and learning process (Wilson, Ritzhaupt, & Cheng, 2020). This approach aims to enhance students' academic achievement (Hew & Brush, 2007), expand learning opportunities beyond traditional classroom boundaries, and facilitate flexible, independent learning experiences (Woodal et al., 2017). Additionally, it aims to foster technological literacy among students (Crawford & Kirby, 2008). Research indicates that student-centered technology integration positively impacts the learning process, promotes enduring learning outcomes, and connects learning to real-world applications (Hakkairien et al., 2000; Howley et al., 2011; Gardner, 2011; Palak & Walls, 2009). Given these objectives, technology integration ensures the effective and efficient use of technology across various

aspects of teaching and learning, encompassing the learning environment, curriculum development, and infrastructure facilities (Yalın, Karadeniz, & Şahin, 2007).

According to prominent studies in the literature (Bitner and Bitner, 2002; Çoklar and Yurdakul, 2007; Gülbahar and Güven, 2008; Hew and Brush, 2007; Koehler and Mishra, 2005), the integration of technology in education emphasizes the development of both students and teachers. This dual focus is crucial for enhancing the effectiveness of the educational process and improving educational quality. Therefore, factors such as curriculum design, student and teacher characteristics, professional development of teachers, school leadership, and school culture play significant roles in successful technology integration in education (Buettner, 2006; Carr and Chambers, 2006; Hamzah, Ismail, and Embi, 2009; Krumsvik, 2006).

As technology becomes increasingly accessible in educational settings, it is crucial to explore effective methods for integrating these technologies into lessons (Dias & Atkinson, 2001). The literature emphasizes that the successful integration of technology involves the participation of all key stakeholders, including researchers, policymakers, and parents (Li, 2007). This collaborative approach is essential for designing an educational environment that will effectively meet the future needs of all students (Peck & Carr, 1997). According to Saglam and Demir (2012), effective technology integration in teaching requires a series of steps: teachers must first identify the subject matter, explore and select appropriate technological tools, adapt these tools to meet specific instructional goals, adjust the learning objectives as needed, define the roles of both students and themselves in using these tools, and ultimately assess the effectiveness of their implementation in the classroom.

In order for technology integration in education to yield successful outcomes, consensus among stakeholders such as administrators, school leaders, teachers, families, and students must first be established (Okojie et al., 2006; Orlikowski, 2000). Subsequently, it is essential to ensure the provision of necessary technological infrastructure, complete bureaucratic processes, and conduct a comprehensive analysis of needs, circumstances, and contextual factors (Çoklar and Yurdakul, 2007; Ertmer, 2005; Okojie et al., 2006; Orlikowski, 2000). Failure to involve all stakeholders in the process or to conduct thorough needs and context analyses may result in time, effort, and financial losses.

In summary, integrating technology into the teaching and learning process involves several stages, including setting learning objectives, selecting teaching methods and strategies, designing feedback mechanisms, planning assessment processes, and implementing monitoring activities. This integration necessitates efforts at both micro and macro levels, encompassing tasks such as instructional design, meeting teachers' professional development needs, and ensuring adequate infrastructure (Okojie et al., 2006). In essence, successful technology integration requires coordinated collaboration among various stakeholders, including policymakers shaping educational policies at the macro level, school administrators as internal stakeholders at the intermediate level, and classroom teachers at the micro level.

1.1.6. Related studies on technology integration in science education around the world

The integration of technology in the educational field has prompted scholars to conduct a large number of studies to evaluate its effectiveness and impact on various variables, including student learning, behavior, achievement, motivation, and more. Researchers now have the opportunity to investigate the classroom applications of new technologies that are constantly emerging. Previous studies conducted in this field have emphasized the significant advantages of integrating technology into the science instructional process, where active engagement is essential. Here are a few studies that were done in the field.

Cai et al. (2022) carried out a quasi-experiment to assess the impact of a Brain Computer Interface based Augmented Reality (BCI-based AR) inquiry tool on primary students' scientific inquiry performance, flow experience, involvement in scientific inquiry, self-efficacy, cognitive load, and science learning. The study involved 41 students, of whom 21 were randomly assigned to the experimental group (EG) and 20 were randomly assigned to the control group (CG). Aged 10 to 13, all of the students were from a primary school in a developed region of China, and they had all used augmented reality beforehand. The CG used simple AR inquiry tools for learning, whereas the EG used the BCI-based AR inquiry tool that integrated attention feedback for scientific discovery. The lever principle, which was chosen from the sixth-grade science textbooks at the local elementary school, served as the subject of the inquiry activity. The data collection tools used were 5-point Likert-type scales (self-efficacy scale, flow experience

assessment scale, and cognitive load scale), a pre- and post-test on science knowledge taken from the local science assessments, and interviews. Results indicated that the AR inquiry tool built on BCI had a favorable influence on students' scientific inquiry. It significantly raised students' self-efficacy in participating in scientific inquiry, helped them experience mental flow, and improved their science learning performance. Furthermore, there was no discernible impact on cognitive strain. The findings from the interviews suggested that students had a favorable opinion of the BCI-based AR scientific inquiry tool.

In the second semester of the 2017–2018 academic year, Zhan et al. (2022) conducted a study to examine students' engagement (behavioral, emotional, and cognitive engagement) in mobile technology-supported science learning. The researchers employed video-based classroom observation to collect their data. This study was motivated by the authors' conviction that the reconfiguration of science learning environments made possible by mobile technologies can change students' learning engagement and, as a result, their performance in science learning. Participants were three teachers (ages 30–35, teaching physics, chemistry, and biology, respectively) and 45 students from one class of the 10th grade at a local senior high school in Chengdu, China. The students were in the age range of 16–17. The implementation involved teaching students utilizing tablets in the classroom a total of 60 science lessons, each spanning 45 minutes and including 20 physics, chemistry, and biology lessons. The effectiveness of the students' engagement in an m-science learning environment was examined using video-based analysis. Consequently, two stationary video cameras were positioned at the front and back of the classroom, and a mobile video camera was used to record the critical activities of the instruction. Students' behavioral engagement in the m-science learning environment was very high, with a participation rate of 95.87%, according to the analysis of the 60 instructional videos. Furthermore, emotional engagement had a 6.36 average value. These findings demonstrated a significant level of emotional engagement on the part of students in the m-science learning environment. Finally, the number for student cognitive involvement was 2.31, indicating that it was still at a basic level in the m-science class.

Gnesdilow and Puntambekar (2022) carried out a study to compare middle school students' scientific explanations in physical and virtual labs. Three sixth-grade science teachers and their students from a public middle school in a small town in the Midwest of the United States took part in the study. Classes were randomly assigned to one of two

conditions under a quasi-experimental design: either the Physical-then-Virtual (P-t-V) condition ($n = 5$ classes and 118 students), in which students performed a physical lab followed by a virtual lab, or the Virtual-then-Physical (V-t-P) condition, in which the sequence was reversed ($n = 6$ classes and 119 students). In an inclined planes unit, the students' understanding of these two scenarios was contrasted. Students engaged in an activity on inclined planes in both physical and virtual (simulation and virtual lab) contexts during the study's implementation phase. The study's analysis employed data from two different data sources, including written post-lab explanations from students and an inclined plane test. Using an analysis of covariance, the results showed that there were no significant variations in the post-test scores of the students based on condition. Results from a repeated measures MANOVA of students' explanations revealed that carrying out a physical lab was less helpful in assisting students in explaining the connections between the science concepts they were investigating as well as using evidence to support their views. Furthermore, regardless of the sequence, students who simply completed a virtual lab outperformed those who completed both types of laboratories. The results also suggested that middle school students would benefit more from doing both types of laboratories if they completed a physical lab before a virtual one rather than the reverse.

Gnidovec et al. (2020), in 2018, carried out pretest-posttest quantitative research using augmented reality (AR) technology and a structure-behavior-function (SBF) model to develop educational materials, including 2D/3D animations, a game, and a video, to supplement the existing 2D representations in school textbooks. The aim of the study was to address the difficulties students had understanding the fundamentals of human anatomy due to its three-dimensionality and complexity as a system. 51 thirteen- and fourteen-year-old students from a Ljubljana nine-year compulsory school in central Slovenia made up the study sample. A paper-based pretest was used to gather data on the students' prior understanding of the subject before the intervention. The students took an AR-based lesson during the intervention phase, and thereafter, they took a posttest on paper. The understanding of the students was assessed using a pretest, posttest, and delayed posttest for the instructional activity, and their acceptance of the AR technology was investigated through a questionnaire. The findings revealed that students' knowledge of the fundamental anatomy and physiology of the human heart and circulatory system, as well as the effects of adrenaline on the human circulatory system, had significantly improved.

Students' enthusiasm for augmented reality (AR) technology demonstrated the greatest level of acceptance of augmented reality (AR) technology as increasing learning, making it user-friendly, and making learning more fascinating and fun. The study also showed the advantages of using 3D animation, movies, and augmented reality technology to comprehend dynamic and complicated biological phenomena.

A mixed-methods case study was conducted by Mills, Tomas, and Lewthwaite (2019) at a public college in South East Queensland, Australia, to investigate the impact of student-constructed animation on middle school students' understanding of plate tectonics. 52 students from two 9th-grade classes led by two teachers made up the participants. At the intervention stage, the students collaborated with their individual classroom teachers to construct a slow-motion representation of the science curriculum's "Changing Earth" subject over the course of four 70-minute lessons. Planning, construction, and presentation were the three main phases of the slow-motion construction process employed in the study. Among the technological devices utilized in the slowmotion creation process were the Internet, pictures, videos, iPads, and the MyCreate software. The quantitative data collection tools used were a two-tiered multiple-choice test and the GeoQuiz, while the qualitative data collection tools were audio recordings. All students in the two case study sessions took the test prior to, and after, they created their slowmotions to evaluate how much the procedure impacted their conceptual understanding. The quantitative data were analyzed using descriptive analysis and the t-test. To examine the qualitative data, coding and exploratory analysis were employed. According to the study's findings, students significantly improved their GeoQuiz scores from the pretest to the posttest, indicating that they gained a better conceptual understanding of the subject matter during the construction process. According to an analysis of the qualitative data, students' conceptions became more sophisticated as a result of "teachable moments," during which they gained knowledge through dialogic teacher-student and student-student interactions.

Chao et al. (2016) conducted a quasi-experimental study to assess the effects of the Gas Frame activity compared to traditional instruction employing a sensor-based lab on the understanding of gas laws and kinetic molecular theory among high school chemistry students. Thirty students, primarily from 10th and 11th grades, were chosen from two chemistry classes at a public high school in a mid-Atlantic state to partake in the research. The Frame group was assigned one class of 16 students, and the traditional group was

given the other class of 14. As a prelude to the two-week unit on gas laws, both groups at the intervention stage studied the same material over the course of two consecutive 90-minute class periods. Throughout the lab sessions, both groups engaged in collaborative work within small groups, with each group typically comprising two or three students. To explore gas molecule behaviors, gas temperature, gas pressure, Boyle's law, Charles' law, the relationship between molecular mass and pressure, and partial pressure, the Gas Frame group utilized the Gas Frame tool along with a paper-based guide. In contrast, the traditional group utilized a sensor-based physical lab during their first-class session, which included comparable physical equipment such as an enclosed gas syringe, a gas pressure sensor, a computer, and a computer interface for data collection and analysis, to examine Boyle's law. The principal instruments employed for data collection in this study consisted of pre- and post-tests, custom-designed to suit the study's objectives. The pretest was given to all students three days prior to the intervention, and the posttest was given to them a week afterward. The Frame group exhibited notable enhancement in their overall achievement, characterized by a substantial effect size, according to paired-sampled t-tests. Furthermore, ANCOVA analysis yielded results indicating no statistically significant disparity in the post-test total scores between the Frame group and the traditional group.

Banda and Nzabanimana (2023) utilized a quasi-experimental study with a non-equivalent control group design to investigate how PhET simulation-based learning impacts secondary school students in Malawi's learning oscillations and waves regarding motivation and academic achievement. Four of the 36 schools in Malawi's Blantyre metropolitan district were selected to participate in the study. 280 students and four teachers participated in the study. The sample had a mean age of 17.5 years ($SD = 1.424$), with 155 (55.4%) males and 125 (44.6%) females. The experimental group had 144 students (79 males), compared to the control group's 136 students (76 males). Pre- and post-tests, along with questionnaires, were used to gather data during a six-week period. In order to establish the baseline levels of students' academic achievement and motivation before the study, both groups were exposed to a pre-test and pre-questionnaires at the beginning of the study. Later, identical teaching and learning objectives regarding oscillations and waves were presented to the two groups. In contrast to the control group, who just received the same kind of instruction without any PhET simulations, the experimental group was exposed to teaching and learning through PhET interactive

simulations. On the post-test of academic achievement, independent sample t-tests revealed a statistically significant difference between the two groups. With a $p > 0.01$, the linear regression analysis revealed that the intervention rather than the characteristics of the students had caused the differences between the two groups in the post-test. The self-efficacy, active learning techniques, performance goals, achievement goals, stimulation of the learning environment, and attitudes toward learning with computers were all significantly different between the study groups according to the ANCOVA test on motivation constructs. The study's findings revealed that the learning of oscillations and waves was enhanced by PhET simulation-based instruction. With the aid of teaching tools and visualizations from PhET simulation-based learning, students were able to comprehend the material more quickly, which raised their levels of academic achievement and motivation.

Liu et al. (2020) undertook a quasi-experimental investigation to examine the influence of an immersive virtual reality-based classroom (IVRC) on learners' achievement in science within an urban public-school setting in China. The study sample included 90 sixth graders, with a mean age of 11, comprising 46 boys and 44 girls. These students were drawn from two classes, with 47 students in one class and 43 in the other. The participants were randomly assigned to either the experimental group or the control group. To ensure comparability of prior knowledge between both groups, a pre-test was administered to all participants before the commencement of the study. At the intervention phase, the experimental group received science lessons in the immersive virtual reality-based classroom (IVRC), whereas the control group received the same lessons using traditional methods of instruction in a conventional classroom setting. Upon completion of the intervention, students in both groups participated in a post-test to evaluate their academic achievement. Additionally, they filled out questionnaires aimed at measuring their engagement with and acceptance of technology. According to the results, the experimental group exhibited significantly higher levels of academic achievement and engagement compared to the control group. Moreover, the results suggested a notable level of technology acceptance for the integration of IVR in science lessons among the experimental group.

Chado et al. (2016) carried out a quasi-experimental study using a pretest and posttest non-equivalent, non-randomized control group experimental design to investigate the effect of a digital game-based instructional strategy on students'

achievement in chemical reactions among senior secondary school students in Niger State, Nigeria. The study involved the purposeful selection of four schools from a total of twenty-three. One hundred and one students—64 males and 37 females—made up the participants of the study. The selected schools were categorized into experimental and control groups. To ensure that both groups had comparable prior knowledge, a pre-test of the Chemistry Achievement Test (CAT) was administered to both groups before the study. The experimental group was instructed during the intervention stage using a digital game-based instructional technique on "chemical lab for chemistry," which had been created by the researcher with assistance from a programmer. In contrast, the control group received the same instruction without any game-based instruction. A post-test was taken by the students to measure their academic achievement following the intervention. The four-week study utilized the mean, standard deviation, ANCOVA, and estimated marginal mean to analyze the data that were collected. The findings of the study revealed that the digital game-based instructional strategy enhanced the achievement of the students. Furthermore, the findings also revealed that the digital game-based instructional strategy favored males more than females.

1.1.7. Related studies on technology integration in science education in Türkiye

In the 2013–2014 academic year, Ünlü, Dökme, and Tüfekçi (2015) conducted an action research pilot study in science education using technology-supported inquiry-based learning. The goal of the study was to determine whether inquiry-based learning activities assisted by technology have an impact on secondary school students' understanding of science subjects, research abilities, and views and perceptions about technology and scientific research questioning. Six seventh-grade students and a teacher made up the participants. The implementation approach included adopting test questions, textbook exercises, teacher and student journals, open-ended questions aimed at developing scientific research abilities, and scientific research activities. Additionally, technology-supported inquiry-based learning was implemented for the science curriculum's "Power and Movement" and "Electricity in Our Lives" units. An achievement test, documents, exam questions, interviews, and observations were used to collect both quantitative and qualitative data. The collected data were analyzed through content analysis. The study's findings showed a substantial difference between the mean scores on the students' pre- and post-tests.

Say and Bağ (2015) conducted a quasi-experimental study in the 2014–2015 academic year to examine the impact of video games on 7th-grade students' self-efficacy toward science. 444 students from the 7th grade, selected from 7 different Turkish regions and attending 7 different schools, made up the study group. From each region, seven experimental and control groups were selected. The experimental group received instruction from a newly developed computer game as supplemental material, while the control groups in each school did not experience any disruption to the teaching process. The levels of the students' self-efficacy in science were assessed in the study using the science lesson self-efficacy scale developed by Tatar et al. (2009). The scale was administered to the students twice: once as a pre-test at the beginning of the first term and again as a post-test at the end of the second term. The findings of the study revealed that the developed computer game was effective in increasing the students' self-efficacy toward science. Additionally, the findings revealed that there were regional variations in the students' self-efficacy.

Civelek et al. (2014) employed a quasi-experimental post-test experiment group design with a control and experiment group to investigate the impact of a haptics-augmented simulation in an immersive VRE on students' achievement in and engagement in physics. Students from Istanbul's Bağcılar Technical and Vocational High School's 11th grade participated in the study in the spring of 2013. The experimental group had 106 students (27 females and 79 males), while the control group had 109 students (84 males and 25 females). The subject of "mass and gravity in the solar system" was taught using traditional methods of instruction for the control group at the intervention stage of the study, while as a treatment, a haptic force feedback application in a VRE was utilized for the experiment group. At the end of the intervention, data were collected using an attitude questionnaire and an achievement test. Descriptive and comparative data analyses were used to analyze the data. The findings of the study revealed that using a haptic force feedback application in a VRE significantly and favorably impacted students' academic performance as well as their motivation, encouragement, autonomy, and learning quality.

Ekici and Pekmezci (2015) conducted a quasi-experimental study to investigate the effect of ICT-supported narratives on middle school students' achievements, self-efficacy perceptions, and attitudes in the Force and Motion science course. 44 sixth graders from Türkiye's Denizli province took part in the study. Participants were divided into two groups: the experimental group ($n = 23$) and the control group ($n = 21$). To ensure that

both groups had comparable prior knowledge, a pre-test was administered to both groups before the study. The experimental group was instructed with ICT-supported short narratives during the intervention period, which lasted for six weeks. The control group, on the other hand, received traditional instruction that followed the curriculum with the use of course and activity materials. At the end of the intervention, both groups received Force and Motion achievement tests, a science self-efficacy perception scale, and an attitude toward science scale. Using SPSS statistical analysis software (v.16.0), the gathered data were analyzed using parametric (independent samples t-tests and paired samples t-tests) and nonparametric (Man-Whitney U test and the Wilcoxon signed-rank test) methods. According to the study's findings, the ICT-supported narratives employed in science instruction significantly improved students' academic performance, self-efficacy perceptions, and attitudes toward science.

A quasi-experimental study was carried out by Ünal and Karakuş (2016) to examine the effects of WebQuests on elementary students' science achievement, attitude towards science, and attitude towards web-supported education. The study involved 49 seventh graders from the Muğla province in Türkiye. Two sets of participants were formed: the experimental group ($n = 24$) and the control group ($n = 25$). A Science Achievement Test, the Attitude Towards Science Scale, and the Attitude Towards Web-Supported Education Scale were administered to both groups as a pre-test prior to the study. The control group students were instructed using concurrent Science and Technology curriculum-based activities during the intervention stage, while the experimental group students were instructed using WebQuest activities during the courses on ecosystems and the solar system. The Ecosystems and Solar System Achievement Test, the Attitude Towards Science Scale, and the Attitude Towards Web-Supported Education Scale were administered to both groups as post-tests at the end of the intervention. SPSS software was used to analyze the gathered data. The results of the study showed that there was a significant difference between the experimental and control groups, favoring the experimental group for science achievement and attitude toward web-supported education, while no significant difference was found between the control and experimental groups for attitude toward science.

Aktaş and Aydın (2016) employed an experimental design with a control group and a pre-test, post-test, and permanence test research design to investigate the effect of smart board use on science education. The study, which lasted for four weeks in the 2013–2014

academic year, included 7th graders from Kastamonu Secondary School. The participants were split into experimental ($n = 37$) and control ($n = 38$) groups. Both groups took an achievement test on the subject of "electricity in our lives" prior to the study. The experimental group studied the unit with supplemental smart board activities throughout the intervention stage, whereas the control group received instruction in accordance with the 2005 Science and Technology curriculum. An achievement test was employed as a post-test to gather data following the intervention. The same achievement test was then used a third time as a retention success test, four weeks later, to measure how well the students recalled what they had learned. The collected data were analyzed using SPSS software and a t-test. The results of the study showed that the smartboard used for science instruction considerably enhanced the academic performance of the experimental group compared to the control group. The permanence test findings additionally showed that the experimental group had a higher recall rate than their counterparts in the control group.

Seyhan (2022) employed an action research method to examine the effect of using mobile technologies in a chemistry laboratory on self-directed learning readiness. 33 11th graders from Türkiye's Sivas Province participated in the study. In the study, sensors integrated with mobile technology were employed in applications that the researchers designed for their guide materials. Students took the Self-Directed Learning Readiness Scale (SDLRS) as a pre-test prior to the study. At the intervention stage, which lasted 10 weeks, the students worked in groups of 4-5 to complete laboratory exercises using mobile technology and sensors to explore a variety of chemistry topics, including Gas Laws, Colligative Properties, Solubility, and Chemical Equilibrium: Let's Find the Equilibrium Constant within the 5E learning model. The Self-Directed Learning Readiness Scale (SDLRS) and a semi-structured interview were used to gather data at the end of the intervention. The data obtained from the interviews were analyzed through content analysis. The findings of the study revealed that the sensor-supported laboratory applications coupled with mobile technologies increased the students' readiness for self-directed learning. Additionally, the students pointed out that the sensor-supported laboratory applications integrated with mobile technology facilitated their data recording process, helped in graphic drawing, and encouraged independent learning.

In an embedded mixed-methods research study, Abdusselam and Karal (2020) investigated how students' academic performance and learning processes were affected by MagAR, a teaching tool that utilizes augmented reality and sensing technology to teach

magnetism. They also sought to understand how students felt about augmented reality. A quasi-experimental study employed a pre-test and post-test in the quantitative section. As additional qualitative data collection approaches, interviews and researcher observation were used in the study. The study involved 69 11th graders from a city in northern Türkiye. Three physics classes were chosen for the study's main implementation, with two control groups—C1 ($n = 25$) and C2 ($n = 20$)—and one experimental group—E1 ($n = 24$). At the intervention stage, C1 received physics instruction in a regular classroom, while C2 received instruction in a physics lab. Additionally, E1 was taught in a physics lab that was integrated with the AR course materials. The three groups were administered an achievement test on magnetism (ATM) as a pre-test and a post-test. In the study's last phase, qualitative research methods like interviews and observation were employed. Statistical analysis tools, SPSS version 17.0, a dependent t-test, and an ANOVA were used to analyze the collected data. The study's findings suggest that AR learning environments are beneficial for teaching physics and increase learning through the incorporation of visual and textual components. The students were seen participating more, seeming more at ease, being able to answer questions about the subject more readily, having more confidence, and displaying higher academic performance levels in physics during learning sessions integrated with AR. The findings showed that AR might be more useful as a supplement to the laboratory setting than as a stand-alone learning environment for the teaching of physics.

A semi-experimental research design with a pre-test and post-test control group was carried out by Sarıoğlu and Girgin (2020) to examine the effect of virtual reality on students' academic achievement in Cell and their attitude towards science. 100 sixth graders from the Orhaneli area of the Bursa province in Türkiye participated in the study, which lasted two weeks in the 2017–2018 academic year. Two sets of participants were formed: the experimental group ($n = 50$) and the control group ($n = 50$). At the intervention stage, presentations and applications on an interactive whiteboard were used to teach The Cell to the control group. The experimental group, on the other hand, received identical instruction but integrated it with virtual reality interactive content called "Journey Inside the Cell." Both groups received the Cell Knowledge Achievement Test as a pre-test and post-test before and after the intervention. Only the experimental group received the Attitude Scale Towards Primary Science and Technology Course as a pre- and post-test. The collected data were analyzed using SPSS software. According to

the study's findings, the VR employed in science instruction significantly improved the academic performance of the experimental group as compared to the control group. Additionally, VR technology greatly impacted the attitude of the students toward science lessons.

Küçük and Büyükata (2022) carried out a pretest-posttest control group experimental study to investigate the effect of simulation on students' academic achievement in a science lesson on light. In the 2013–2014 academic year, 98 seventh graders from a secondary school in the central Çanakkale province of Türkiye took part in the study. An experimental group ($n = 52$) and a control group ($n = 46$) were established among the participants. As a pre-test prior to the intervention, both groups completed a Science Academic Achievement Test (SAAT) on the topic of light. Throughout the intervention stage, the experimental group engaged in simulation activities to study the unit, whereas the control group received instruction employing a constructivist approach. To collect data after the intervention, a Science Academic Achievement Test (SAAT) was administered to both groups as a post-test. A t-test and SPSS software were used to analyze the data collected. The study's findings revealed that the integration of simulation into science instruction significantly improved the experimental group's academic achievement relative to the control group.

Dağdalan, Taş, and Kaya (2021) carried out an experimental study with experimental and control groups to examine the effects of virtual reality-supported science education on the subject of "Nervous System" from the unit of "Controller and Regulatory System" students' cognitive levels and metacognitive awareness. 108 6th grade students from a public school in Altınordu district in the city of Ordu in Türkiye participated in the study in the 2018–2019 academic year. Three groups of participants were created: the control group (CG) ($n = 36$), the first experimental group (EG1) ($n = 36$), and the second experimental group (EG2) ($n = 36$). Prior to the intervention, all groups completed a pre-test that included the Cognitive Level Assessment Scale (CLAS) and the Metacognitive Awareness Scale (MAS). At the intervention stage, virtual reality was utilized in the lesson with the first experimental group (EG1), animation was used to instruct the second experimental group (EG2), and a course book and various Educational Informatics Network applications were used to instruct the control group (CG). Following the intervention, all of the groups were administered another post-test that included the Cognitive Level Assessment Scale (CLAS) and a Metacognitive Awareness Scale (MAS).

The collected data were analyzed using SPSS 22 package software. The study's findings revealed that, considering virtual reality technologies were integrated into the instruction, the students in the first experimental group (EG1) performed better than those in the other two groups. Additionally, it was noted that EG1—the first experimental group—exhibited greater metacognitive awareness than the other groups.

1.2. Statement of the Problem

The integration of technology into the instructional process brings a wealth of potential advantages. According to Koç (2005) and Tam (2000), the outcomes of teaching and learning in the classroom have undergone a significant transformation thanks to the use of technology. Along with offering endless access to knowledge and easily accessible information online, technology has also empowered students to manipulate data, investigate relationships, actively and consciously process information, create personal and communally shared meaning, and reflect on the learning experience. Technology has provided students with the chance to consider a range of perspectives to build their own understanding of diverse subjects.

Several research investigations have underscored the importance of teaching techniques that incorporate technological tools and equipment in meeting students' instructional requirements while sustaining their motivation and boosting learners' thoughtfulness, which is identified as a crucial indicator of learners' academic success (Xu et al., 2021). Liu et al. (2022) asserted that the incorporation of technological tools and equipment into instruction enhances learners' conceptual understanding and educational performance. Additionally, it allows learners to maintain relationships with their teachers and classmates through a variety of social media platforms, assist them in overcoming academic obstacles, and maintain their involvement in educational tasks (Liu et al., 2021). Understanding the significance of learners participating actively in the instructional tasks, Liu et al. (2021) recommended instructors create cooperative tasks using the computer-supported collaborative concept mapping approach to foster a cooperative instructional setting, thereby also heightening learners' attention.

Ly-Hoang, Sun, and Ulanoff (2022) opine that technological tools are a vital and practical way to modernize education, whether it be online or in person, according to research that shows how a student-centered approach using technology maximizes the potential for student learning and creativity. Supporting long-term student academic

achievement requires utilizing technology to improve the capacity to exhibit scientific literacy and enrich learning experiences.

The Fred Rogers Center for Early Learning and the National Association for the Education of Young Children (NAEYC) have stated their opinions on the possible value that students might gain from technology-enhanced learning. In a corporate statement they released, they expressed their thoughts on this matter and made the argument that interactive media and technology are tools that, when used purposefully by teachers and within the parameters of developmentally appropriate practice, can promote effective learning and development. The use of interactive media and technology by students is becoming a bigger part of their everyday lives. (NAEYC & Fred Rogers Center for Early Learning and Children's Media at Saint Vincent College, 2012, p. 5).

According to Prensky (2001), digital natives are children from kindergarten through college who represent the first generations to grow up with new technology. These children have spent their entire lives surrounded by and using computers, video games, digital music players, video cameras, cell phones, and other tools of the digital age. These children will benefit from technology-integrated instruction in which they are not constrained by the curriculum or available resources; rather, practical tasks in a technology-based course are created to aid in stimulating their grasp of the subject.

According to Finger and Trinidad (2002), through the use of various instructional strategies that integrate technological tools like videos, simulation, augmented reality, virtual labs, data storage, database use, mind-mapping, guided discovery, brainstorming, music, and the World Wide Web (WWW), the instructional process can be made more engaging and meaningful. Additionally, students will benefit from technology-integrated instruction in which they are not constrained by the curriculum or available resources; rather, practical tasks in a technology-based course are created to aid in stimulating their grasp of the subject. Furthermore, it gives teachers the opportunity to devise engaging lesson plans that will involve students in active learning.

Windschitl and Sahl (2002) asserted that teachers' instructional pedagogies can be transformed when technology is integrated into instruction. This transformation mostly depends on the teachers' beliefs about learners, their understanding of the roles of technology, and their knowledge about how technology could enhance the teaching and learning of science. Furthermore, this can enhance teachers' effectiveness in instruction delivery, which would otherwise be difficult in a traditional instructional setting

(Churchill, 2009). This upside also extends to how technology simplifies teachers' work by altering their visualization of lessons and also broadening learners' perspectives (Bozdoğan, 2011).

While it still remains undisputed that technology possesses a great deal of significance when implemented in the teaching and learning process, it is equally imperative to assess thoroughly how it promotes effective learning (Savoy et al., 2009). Technology integration provides a multitude of instructional strategies that foster students learning and also allow versatility in the instructional process. Teachers can provide a flexible learning environment to accommodate the various requirements of students in their study of science by making effective use of technology. Hence, it is imperative for teachers to employ the best technological tools that will address the educational needs of all the students and, in essence, assist them in achieving their instructional objectives (Churchill 2009; Clark 2008; Kerawalla et al. 2009; Marx et al., 1997, cited in Wang et al., 2011).

In the educational discipline, a multitude of groups, including policymakers, researchers, teachers, and employers, have expressed their thoughts on the wide range of potential advantages they see technology bringing to both students and teachers. In the UK, for instance, the National Council for Educational Technology (NCET) (1994) cited more than twenty of these advantages, including:

- Improving the effectiveness of pupils' learning
- Boosting pupils' motivation
- Amplifying pupils' sense of accomplishment
- Granting pupils access to diverse and extensive data and information sources
- Cultivating pupils' autonomy in learning
- Alleviating pressure on pupils by allowing them to progress at their own pace
- Advancing pupils' literacy skills
- Prompting instructors to reconsider their instructional methods
- Liberating instructors from administrative tasks, enabling them to concentrate on pupils' education.

It is impossible to dismiss the potential of technology for science instruction, given the variety of uses and perceived benefits. According to Harris (1994), there are five main ways that technology is having an impact on science:

- Proficiency in utilizing technology to exchange information.

- Competence in leveraging advancements in technologies and evaluation, as well as the procurement, machining, and handling of data
- Skill in employing models and simulations
- Capability to access, sift through, and work with large volumes of data
- Facilitating learning that places an emphasis on knowledge comprehension, analysis, and implementation, which lessens the need for laborious mathematical operations.

In a nutshell, using technology can improve the effectiveness and efficiency of science instruction, but only when it is integrated properly into the instruction. Technology integration is done best when the science teacher has a clear understanding of the true nature of science (i.e., both content knowledge and process skills), develops a working knowledge of the function and utility of the technology, and aligns technology use with the learning objectives of the course (Davies, Sprague, & New, 2008).

Undoubtedly, the emergence and proliferation of technology in the educational field have led to a total transformation in the instructional process, moving from traditional instructional methodologies to more constructive strategies where students take center stage in the entire learning experience. Numerous studies have emphasized the advantages that using technology in the teaching and learning process offers to both instructors and students in the classroom. The significance of technology integration in the instructional process has been acknowledged globally, leading to the development and implementation of numerous technological devices. This has made education more accessible, stimulating, engaging, and successful for both teachers and students.

In the study conducted by Yalçın-İncik and İncik (2022), students reported that integrating technological tools into lessons offers numerous advantages. These benefits include facilitating easier learning, enhancing audiovisual learning experiences, and providing access to a wealth of information. Moreover, in the study conducted by Karaca (2011), students reported that they learn more effectively and achieve greater success in technology-supported lessons. They also believed that the use of technology enhances their motivation and participation in class, and improves their communication with teachers in such lessons.

Day in and day out, cutting-edge educational technological tools of the 21st century are being produced and subsequently integrated into the instructional process to enhance student learning. However, a problem emerged when teachers identified ineffective

technology integration as an issue (Albirini, 2006). The mere availability of technological tools, the instructor's ability to operate them, and their use in the teaching and learning process are not enough to effect the desired change in student learning. The integration of technological tools in teaching and learning is not just about the kind of technology utilized; rather, it pertains to the rationale behind and the specifics of "how" it will be integrated to ensure effective learning (Stoilescu, 2015).

Given the many studies that have explored the benefits gained from the integration of technology in the instructional process, such as enhancing students' success, there were some concerns that were raised likewise (Nakayima, 2011, Jamieson-Proctor et al., 2013). This has prompted several studies to investigate and evaluate the variables that hinder instructors from integrating technology into their instruction (Capan, 2012; Virkus, 2008; Zhang, 2013; Dudeney, 2010). Teachers play crucial roles in the classroom, especially when it comes to the integration of technology in the instructional process, which could increase the achievement of the students, their creativity, and their thinking skills. Cassim and Obon (2011) opined that there is a high correlation between teachers' beliefs and technology integration. This is an indication that the beliefs teachers, who are the implementers of the curriculum, have towards technology serve as a major barrier that hinders them from integrating technology into their instruction.

It was noted by Dawson (2008) and Varma et al. (2008) that instructors confront various obstacles that make it difficult for them to effectively integrate technology into their science instruction. According to some teachers, it is difficult for them to simultaneously integrate technology into their instruction while also working in their laboratories. Other instructors have stated that their inability to effectively integrate technology into their instruction is due to their lack of confidence and technical problem-solving abilities (Sorensen et al., 2007; Varma et al., 2008). Other instructors have mentioned difficulties using technology (Valanides & Angeli, 2008), a lack of expertise in integrating technology into their instruction, and a lack of experience aligning technology with their school curricula as their reasons for not integrating technology into their instruction (Varma et al., 2008).

Afshari et al. (2009), Hew & Brush (2007), and Sprague (2004) all claim that instructors' attitudes toward technology vary. Technology integration will be difficult for instructors who have spent their entire careers teaching without it. There might be several reasons for this hesitation, such as a lack of pertinent information or skills, poor self-

efficacy, and preexisting belief systems, among others. In order to change their pedagogy to promote technology integration, it is essential for these types of instructors to receive training on how to incorporate technology into the learning process. Baylor and Ritchie (2002) went on to say that instructors who do not believe they possess the necessary knowledge to integrate technology effectively in their instruction will not even be motivated to use it. So, it is crucial that innovators take into account how instructors feel and what they think about using technology in their instructional process (Vanderlinde & Van Braak, 2011).

Leh's (2005) research revealed that instructors recognized their inability to fully integrate technology into their practices due to various constraints, including organizational, administrative, pedagogical, or personal factors (p. 19). Leh argues that teachers perceive technology as presenting multiple challenges rather than providing a solution. This might be an indication that the integration of technology in the instructional process can create challenges for teachers, which may vary depending on their individual contexts and experiences. Given the diverse nature of these challenges, it is imperative for researchers to take a nuanced, multifaceted approach to problem-solving. By identifying and addressing specific issues faced by teachers one at a time, researchers can develop targeted solutions that are relevant to the unique obstacles that teachers face. This approach supports a more effective response to the complexities of technology integration, ultimately improving the overall success of technology integration and supporting better learning outcomes for students.

In an attempt to ensure that technological tools are effectively integrated into the teaching and learning process, it is imperative for instructors to focus on variables beyond availability and the ability to use a piece of technology. Factors such as those determined in the Technology Integration Framework by Sağlam and Demir (2012) need to be taken into consideration. Important factors include the best technological tool available for a given topic, the appropriateness of the tool in relation to the students' level, and the teacher's knowledge about the tool, including its significance, operability, and limitations. The most crucial of all factors is how to integrate technology into the teaching and learning process. Under this factor, there is the need to consider whether the technology is going to be used as a replacement, amplification, or transformation, what to do in case a problem is encountered, which part of the lesson plan will be integrated, how to arrange the classroom to accommodate the technology, and how to supervise the students during

the process. Science teachers might investigate their own teaching practices regarding how to effectively integrate technology into their curriculum through action research.

Action research, also known as teacher research, has the potential to enhance teachers' instructional practices. The literature includes several action research studies conducted by science teachers, such as those by Wang et al. (2011), Kuo (2015), and Ünlü and Dökme (2020). These studies suggest that the availability of technological tools is not a significant issue in integrating technology into science education. Instead, the challenge lies in effectively incorporating these tools into science courses, which is the gap this present study aims to address.

Nevertheless, additional studies on the integration of technology into science courses are necessary for science teaching practitioners. The lessons learned from teaching practice can illuminate future practices for other science teachers. Solutions to obstacles encountered by a science teacher can be applied to other science classrooms. Therefore, more science teachers should engage in action research to effectively integrate technology into their lessons. These action research studies must be conducted on a scientific basis to hold value in the scientific literature and benefit practitioners and educational scientists through their scientific reports.

This study investigated how to effectively integrate technological tools into the science teaching-learning process. Within this framework, action research was conducted, and the best practices to carry out before, during, and at the end of the lesson in which technological tools were integrated were explored. Furthermore, how the lesson and classroom were planned to accommodate the technological tools were equally explored.

1.3. The Aim of the Study and the Research Questions

The general aim of this study is to investigate how to integrate technology into the science teaching and learning process. To guide the study, four key research questions have been formulated, and answers were sought for them.

1. Which technology is used to improve students' understanding of key science concepts at the beginning, during, and at the end of the implementation week's courses in this study?
2. What are the students' views on technology-supported science lesson activities?

3. How are the lesson plans organized with technology integration in the science lesson?
4. What are the problems encountered in the process of integrating technology into science lessons and their solutions?

1.4. Significance of the Study

Technology integration in the teaching and learning process has become a very important aspect of education. The purpose of this study is to investigate how technology can be effectively integrated into the teaching and learning process of science. Considering the pace at which technology is evolving, there is a need to investigate how technology might be used effectively to improve the teaching and learning of science, as well as the benefits and drawbacks of doing so. The findings of this study could help drive the formulation of evidence-based guidelines and recommendations for educators and policymakers looking to enhance the standard of science instruction by identifying effective practices and strategies for technology integration in the teaching and learning of science. Finally, the findings of this study could also help to support more engaging, effective, and efficient science education, with the potential to positively impact the lives of students and instructors alike.

The findings of this study could also provide detailed information to other teachers who would want to carry out similar studies on how to integrate technology in the teaching and learning of science. The findings could serve as an example and provide other teachers with a range of strategies, techniques, and technological devices they could use to effectively integrate into their own teaching practice. Moreover, the findings could also help teachers advance their skills and knowledge in the use of technology in the teaching and learning of science by offering insight for professional training and development programs on how technology integration can impact students' learning of key scientific concepts. Additionally, the findings could also provide thorough and in-depth information to teachers on the selection and integration of technological tools as well as strategies for integrating those tools into lesson planning and delivery in the teaching and learning of science.

The study's findings can also be used to highlight students' views on how technology can influence their ability to learn science. The perceptions of the students about how technology is integrated into the science teaching and learning process might

offer important insights into how successful or unsuccessful technology integration could be. Also, by using these insights, teachers would be able to modify their lesson plans to better suit the requirements, preferences, and expectations of their students. This could raise the standard of instruction.

The findings of this study could inform future scientific research on integrating technology into the middle school science curriculum. Therefore, curriculum researchers might benefit from the insights gained from action research conducted in specific science teaching and learning processes at schools, using each study as a hypothesis for future curricular investigations.

Last but not least, the findings of this study can provide the government and policymakers with insightful information and understanding of the influence of technology, as well as its benefits and limitations in integrating them into the teaching and learning of science. Also, the findings can offer insightful information on the best strategies to integrate technology into science courses, which can be utilized to guide educational and political decisions. From this study, implications concerning the importance of funding technical infrastructure and support services, as well as teacher training and professional development, may be deduced. Lastly, policies that support the integration of technology in education may be created using the study's recommendations, which will eventually be beneficial for both students and teachers.

1.5. Limitations of the Study

Limitations are inevitable within each study. It is thus imperative that such limitations be taken into consideration during the study. Within the framework of this study, the following were the limitations taken into consideration:

1. The study was limited to only eight 7th-grade students from one international private school in Ankara, Türkiye, during the first semester of the 2023–2024 academic year. The units covered included forces and motion, speed, and describing movement, using technological tools such as videos, animations, 2D and 3D simulations, Wordwall, ESL Games Plus, and Kahoot.
2. Data were collected through validity committee meeting records, researcher and student reflection journals, observation field notes and protocols, semi-structured interviews, questionnaires, and lesson plans.
3. The implementation process lasted only three weeks.

4. No follow-up implementation was conducted to assess the long-term effects of integrating technology into the science teaching and learning process.

1.7. Definition of Terms

Science: It is a continuous process of investigation and experimentation in order to widen people's understanding of the natural world. It involves the gathering and recording of knowledge to find answers to the questions and challenges that life poses every day (Oddoye, Taale, Ngman-Wara, Samlafo, & Ofori, 2011).

Technology: Refers to any tool, device, software application, or web-based resource that boosts the productivity of teachers and students and has the potential to enhance learning. It can also increase efficiency in planning, developing, instructing, and delivering educational objectives. When properly implemented and overseen within an educational environment, technology has the potential to improve learning outcomes (Mitchell et al., 2016; Wing Fat Lau & Hoi Kau Yuen, 2013).

Information and Communication Technology: Information technology that centers on cohesive communication and the integration of telecommunication devices. (Mama & Hennessy, 2013).

Technology integration: Refers to incorporating technological components, software tools, and digital platforms into instructional content sessions (Safar & Alkhezzi, 2013).

Technological Pedagogical Content Knowledge (TPACK): This is a framework that underscores the interconnectedness of technology, pedagogy, and content, delineating three overlapping domains of knowledge: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), and Technological Pedagogical Knowledge (TPK). These domains converge to form the central TPACK, providing educators with a structured approach to integrating technology effectively into their instructional practices. This framework serves as a valuable guideline for teachers seeking to enhance their teaching methodologies through the strategic use of technology. (Koehler & Mishra, 2009).

Web 2.0: Refers to a platform that offers services that allow users to participate, interact, collaborate and share (Brown and Adler, 2008).

Simulation: Simulations are software applications designed to enable learners to systematically engage with hypothetical scenarios, interact with various elements within

those scenarios, and observe the effects of their interactions on the simulated environment.



2. METHODOLOGY

In this chapter, the research design that was employed is explained. Next, the implementation process, the research setting, the participants and the researcher's roles, data collection instruments, data analysis and interpretation, validity and reliability studies, precautions taken against researcher bias, and ethical issues are presented.

2.1. Research Design

A research design is a strategy or framework that specifies how information will be gathered and analyzed throughout a study. It acts as the study's road map, outlining the techniques and steps for data collection and analysis as well as the format for presenting the findings (Cresswell, 2009). Research designs, in accordance with Kerlinger (2000), enable the researchers to provide the most precise, accurate, and thorough responses. Moreover, it aids the researcher in responding to inquiries based on the research design (Ary et al., 2013). According to Ary, Jacobs, Razavieh, and Sorensen (2010), researchers should select a research design that will enable them to accomplish the study's objectives. What researchers employ as a design relies on what they are exploring and examining.

In view of this, this study aimed to investigate how to effectively integrate technology into the science teaching and learning process. In order to achieve this aim, the researcher employed an action research design where he integrated various technological tools into the science teaching and learning process with the students.

2.1.1. Action research

Action research, according to Riel (2020), entails a methodical approach to reviewing data. The findings of this kind of study are useful and pertinent and can influence theory. According to Gorski (2018), action research differs from other types of research in that the relevance of the results to the researcher and the local collaborators is prioritized over the universality of the findings. Action research is a continuous process of assessment, recommendation, practice, reflection, and reevaluation. It is formative rather than summative. Also, it is change-oriented and carried out with the presumption that change is required in a particular setting.

Robson and McCartan (2016) opine that action research may be distinguished principally from other research designs by its objective, which is to change or influence some element of the subject of the investigation. It is concerned with the emancipatory

intent behind research in this sense. The classic research goals of description, comprehension, and explanation are supplemented with the encouragement of change. They also expressed that action research's two main tenets are involvement and improvement. First, a practice of some type has to be improved. Then, practitioners need to have better knowledge of the practice. Finally, the environment in which the practice is conducted needs to be improved.

The change that this study intended to bring was aimed at helping address the difficulties that instructors face when integrating technological tools into the teaching and learning process. Additionally, among the changes that the study aimed to bring about was the improvement of the researcher's instructional practice through the integration of technology. The students, who were also crucial participants in the study, were intended to gain an enhanced understanding of some scientific concepts as a result of the integrated technological tools.

Since action research encourages instructors to consider the dynamics of their classrooms, consider the behaviors and interactions of students, confirm and question current methods, and take risks in the process, it greatly adds to the professional perspective that teachers adopt. With action research, teachers may get new insights into their own and their students' actions, which gives them the power to decide what to change and what not to change, link old knowledge to new information, learn from mistakes, ask questions, and methodically identify solutions (Fueyo & Koorland, 1997). In action research studies, the research design develops during the course of data collection, analysis, and decision-making for the study's subsequent phases. At every stage of the study, lead researchers collaborate with participants as co-researchers (Merriam & Tisdell, 2016).

Individual teacher-level action research was employed in this study. According to Gay, Mills, and Airasian (2012), individual teachers engage in action research at this level to advance their knowledge and skills in their own classrooms. Individual teachers frequently want to learn about elements of their classrooms that are particular to them and their students. Hence, in this study, the aim was to investigate how to integrate technology into the science teaching and learning process in a single classroom. As an alternative, instruments for interviews, observations, and reflective journals were created to solicit information from the students on the subject being studied.

In this study, practical action research, a type of action research, was employed. Similar to how the study placed emphasis on "how" to effectively integrate technology in the science teaching and learning process, practical action research also places more emphasis on the "how-to" approach to action research designs. Practical action research has the underlying presumption that, to some extent, individual instructors or teams of teachers are autonomous and can choose the type of investigation to be conducted (Gay, Mills, & Airasian, 2016). Also, the goal of practical action research, according to Ballenger (2009), is to improve teaching practices while also allowing the teacher-researcher to grow as a reflective practitioner and provide new information about their students.

Teachers frequently develop practical action research as a result of their curiosity or, as Stringer (2014) states, "puzzling moments." The puzzling moment that influenced this study was the question of the science teacher regarding the effective use of technological tools in the teaching and learning of science. Additionally, the plan-act-observe-reflect cycle proposed by Stringer (2014) was implemented to execute a change in the instructional process. This was carried out in science, and observation, interview, and reflection journals were used to collect data, and action plans for subsequent implementation were drawn from the findings as expounded by Gay, Mills, and Airasian (2016). According to the practical action research approach, teacher researchers select their own areas of interest, decide how to gather data, evaluate and interpret the results, and create action plans based on their findings (Gay, Mills, & Airasian, 2016).

According to Stringer (2014), action research has the following contributions:

- Action research provides the framework for developing successful solutions to extremely important classroom and school issues, such as classes that are particularly combative, unusually difficult groups of students, underachievers, and various external demands.
- Action research is also a helpful technique for day-to-day planning in the classroom, including lesson planning, creating teaching tactics, and assessing students, as well as more involved activities like designing a syllabus, creating a curriculum, and evaluation.
- Action research can be used as a management tool by school administrators to build strategic objectives with families and the community, develop programs, and engage in program creation and evaluation (Stringer, 2014).

2.1.2. Action research process

There are numerous action research models available to assist researchers in carrying out an array of action research. These models have been utilized in a variety of fields, including agriculture, health, social work, production, and social development, according to Mills (2007). Within the framework of this study, the Stringer (2014) researcher model was employed.

According to Stringer (2014), the fundamental action research procedures may be summed up in a straightforward "look-think-act" pattern. As they carry out a study, researchers look, think, and act while concentrating on a particular problem.

Look: The process of carefully observing something by looking, hearing, and capturing information (data). Under this section, various technological tools were integrated into the teaching and learning of science. During the implementation, the researcher made careful observations of the setting and what transpired. Attention was given to the kind of technological tools utilized and how they were integrated; which activities were carried out using technological tools from the beginning to the end of the course; the students interaction with technological tools; the students' participation in the lesson; the problems encountered and how they were resolved; and how the use of technological tools affected the classroom environment.

Think: Examining the data to spot key characteristics and components. At this stage, the data collected from the implementation were analysed. The data included an observation protocol and an observation field note recorded by the researcher. The data collected from the students included a reflection journal, a semi-structured interview, and a questionnaire. Each week's complete set of data was analysed by the researchers, and the data and the findings were presented to the validity committee. Committee meetings work as a reflection time for the action research cycle. During the meetings, the problems that arose and the solutions for the subsequent week were discussed.

Act: After coming up with remedies for the problem under investigation using the newly formed information and the collected data being presented to the validity committee members, the members deliberated on the data, and solutions were found for the problems encountered during the implementation. The solutions were used to make action plans, which were implemented in the subsequent implementations. During the act stage, solutions that were decided during the committee meeting are reflected in the lesson

plans of the following week's lessons, and the teacher, as a researcher, implements the lesson plans with new solutions.

This straightforward procedure was carried out so that problems were sought, observed, examined, and solutions formed and implemented until a successful result was obtained. This was represented as a helix, which is displayed in Figure 1.

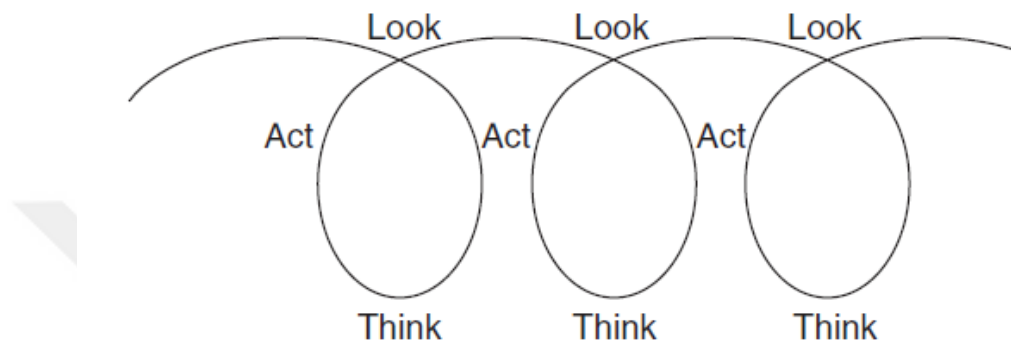


Figure 1. *Action Research Helix*

Source: Stringer, E. (2014, pp. 4). *Action Research in Education*. (2nd ed.). England. Pearson Education Limited.

Stringer (2014) provided a five-process cyclical breakdown of the action research cycle, which includes designing, gathering data, analyzing data, communicating results, and taking action. The following is a succinct explanation of these processes according to Stringer (2014):

- Designing: Organizing rigorous techniques of investigation, carefully defining the problem to be explored, and evaluating the work's ethics and validity.
- Collecting data: This entails employing a number of instruments and gathering data from a wide range of sources.
- Analyzing data: This involves determining the salient aspects of the problem being looked into.
- Communicating outcomes: This entails informing pertinent audiences about the study's findings.

- Use: This entails putting the study's findings to use in an effort to resolve the problem it was designed to address.

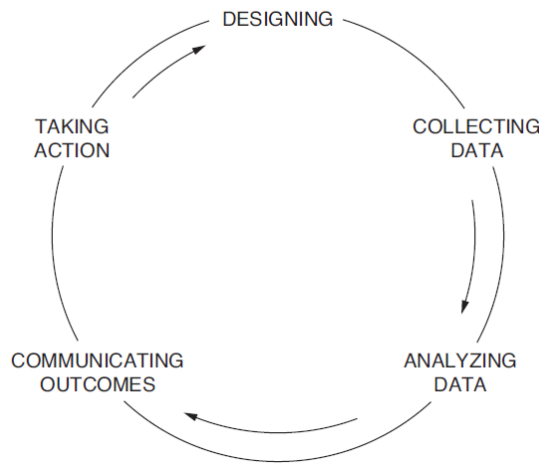


Figure 2. *Action Research Cycle*

Source: Stringer, E. (2014, pp. 5). *Action Research in Education*. (2nd ed.). England. Pearson Education Limited.

The cyclical nature of the action research cycle seen in Figure 2 may alternatively be portrayed as a sequence, moving from one process to the next. Together, the processes overlap and provide a comprehensive action research process.

2.2. Pilot Study

Prior to the main implementation of the study, a pilot study was conducted with a group of students. During the pilot study, the students participated in a science lesson focused on the topic of paper chromatography. Various technological tools were employed throughout this lesson. These tools included an instructional video sourced from YouTube, a simulation from Amrita OLabs, and Wordwall for assessment purposes. Following the lesson, data were collected from the students using observation protocols and focus group interviews. These data collection instruments were meticulously designed and subsequently reviewed based on the expert opinions of four faculty members from the Department of Curriculum and Instruction at Anadolu University. The collected data were then analyzed in collaboration with the first validity committee member to ensure the reliability and accuracy of the findings.

2.3. Implementation Process

The implementation of the action research process began with the establishment of the validity committee. A validity committee is an established group of people who scrutinize and assess the entire research process, including the research design, techniques for gathering information, findings, and analysis, with the goal of guaranteeing that the entire research process and the findings are valid, reliable, and untainted by any kind of bias. The validity committee established within the context of this study was composed of two academic supervisors and a subject matter expert who works as a science teacher at the same school as the practitioner researcher.

The researcher and the members of the validity committee collaborated closely, jointly determining the course of action for the study. Together, they identified the topic and lesson for implementation. The validity committee members were actively involved in developing and agreeing upon the data collection instruments, and they reviewed the lesson plans to ensure they were appropriate. Additionally, the technological tools slated for integration into the lesson underwent scrutiny by the validity committee members. Following each implementation, the collected data were presented to the validity committee for a macro-analysis of the findings. Subsequently, action plans for the next steps were devised and implemented in the subsequent lesson.

During the first semester of the 2023–2024 academic year, the implementation was carried out with 7th graders at a private school in Ankara. The study spanned three weeks, during which the researcher led students in five-hour science lessons each week. Various technological tools were employed based on action plans developed in collaboration with the validity committee members.

During the implementation, various data collection instruments such as reflection journals, observation protocols, semi-structured interviews, and questionnaires were employed to gather comprehensive data. Before the implementation, the researcher documented pre-implementation plans and strategies in a reflection journal, outlining how technological tools would be integrated into the teaching and learning process. As the students' science teacher, the researcher assumed the dual role of participant and observer in the lessons. This method allowed the researcher to actively engage in the teaching and learning process while simultaneously observing what was transpiring in the classroom. To ensure that crucial events from the lessons remain unaltered, the researcher completed observation field notes and an observation protocol, documenting all activities

during the implementation. Subsequently, a post-implementation reflective journal was written, providing a detailed account of the events that transpired during the implementation.

Data collected from students included semi-structured interviews, questionnaires, and reflection journals. The data that was collected with these instruments laid much emphasis on the type of technological tools integrated into the lesson and, most importantly, how the tools were integrated. Furthermore, the effect of the technological tools on the students understanding of the lesson, the problems encountered and how they were resolved, as well as the students' general views on the integration of technological tools into the science lesson, were also emphasized.

The action research implementation process, encompassing the planning stages from selecting the research topic and methodology to crafting data collection instruments, defining the roles of both the researcher and the validity committee members, executing action plans, analyzing findings, and reporting results, is illustrated in Figure 3.

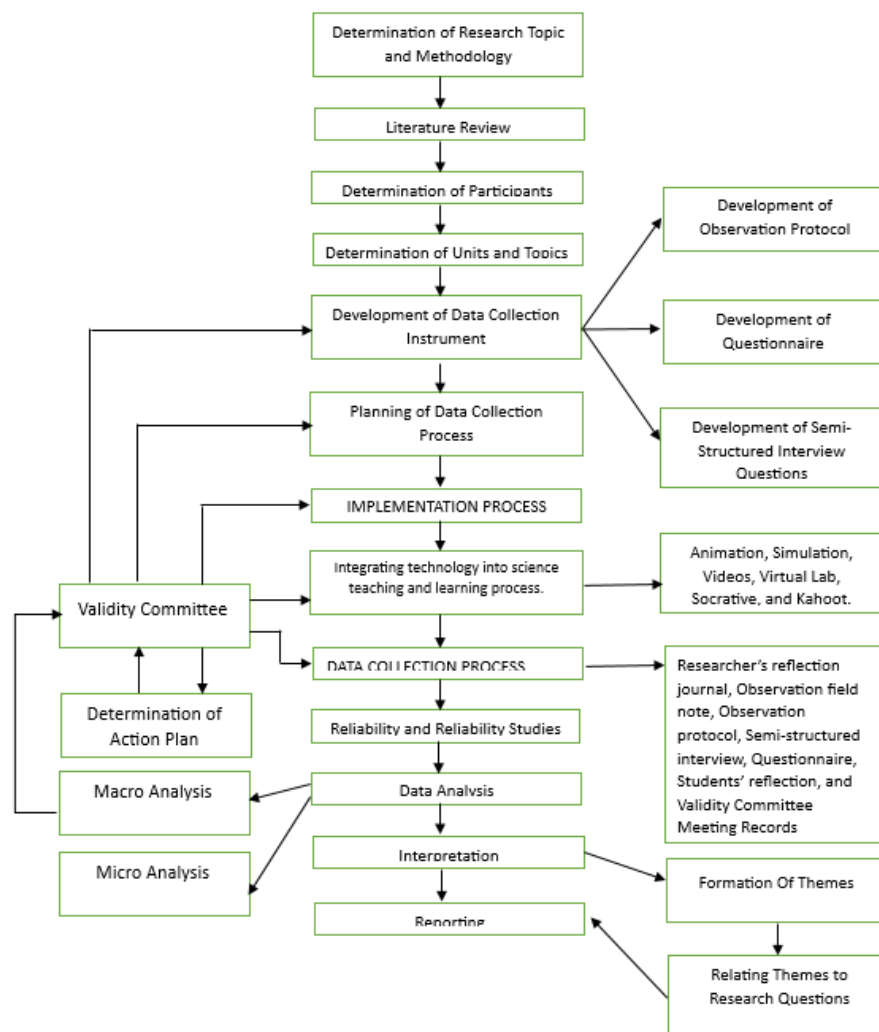


Figure 3. *Action Research Implementation Process*

The researcher presented the macro-analysis of the data obtained from the implementation to the validity committee members. During the validity committee meetings, which were all held on Zoom, a virtual meeting platform, the problems encountered by the researcher and the students during the implementation, the solutions devised to resolve the problems, whether the problems were truly resolved, and whether there was a need for finding more solutions to the problems were deliberated upon. Finally, an action plan was devised for the subsequent implementation. These processes continued throughout the period of implementation. The implementation ended after all the problems encountered were successfully addressed.

Following the end of meetings with the validity committee and the development of an action plan for the subsequent implementation, a technology integration timeline was developed in preparation for the upcoming implementation. This timeline facilitated effective time management for the researcher during the implementation. It outlined the technological tools to be integrated into the lesson, identified the stage of the lesson for integration, and specified the duration of each tool's utilization. The technology integration timeline developed for the second implementation is presented in Appendix 1.

The technological tools that would be integrated into the lesson and at what stage were explained to the students prior to the lesson. This was done in an effort to lessen the novelty effects that could affect how well students learn when utilizing new technologies. Additionally, the seating arrangements for the students were carefully considered because the study was designed around cooperative learning, a sort of social constructivist learning. To participate cooperatively in the lesson, the students were split into two groups. Each group was provided with the needed technological devices and tools for the lesson. These tools were mainly laptops and smartphones. Other software installed or opened on the laptops were 2D and 3D simulations and assessment tools like Kahoot.

After arranging the classroom to accommodate the technological tools, the lesson began with a quick five-minute assessment of the lesson's objectives and the students' relevant prior knowledge. Subsequently, the technological tools, primarily videos and animations, were introduced to the students, followed by a discussion of the lesson content, lasting approximately twenty-five minutes, culminating in the first 40-minute lesson. The second 40-minute lesson involved students engaging in simulation tasks and summarizing the lesson, which took about twenty minutes. The remaining twenty minutes were dedicated to assessing the lesson using technological assessment tools. This makes up the 80-minute lesson for each implementation for three weeks. Following this, data were collected from the students through reflection, semi-structured interviews, and questionnaires.

2.4. Research Setting

This study involved students from a private K–12 school situated in the capital city of Türkiye, Ankara. The school is an eclectic mix of cultures and languages, with students from 47 different countries as its student body. Implementing both the Turkish national

curriculum and the International Baccalaureate (IB) program demonstrates the school's dedication to giving a top-notch education that promotes critical thinking, creativity, and global citizenship. The school emphasizes the value of extracurricular activities in addition to academic rigor and provides a range of alternatives, including sports, music, drama, and debate. The structure of the school, which has distinct facilities for elementary, middle, and high school students, demonstrates its dedication to providing contemporary education. This guarantees that students receive an age-appropriate education that is suited to their developmental requirements. The school has six different campuses around Türkiye, and this current study was carried out at the school's recently opened Ankara campus, which currently has 160 students enrolled. The institution was the perfect place to carry out the research on educational practices and outcomes that this present study examined because of its commitment to offering students a well-rounded education that equips them for success in a globalized society. The setting for this study was an ideal setting to acquire insights about the integration of technology into science instruction due to the varied student body, technological infrastructure, cutting-edge instructional resources, and dedication to academic performance.

The main reason for selecting this school as the research setting is that the researcher works there as a science teacher. Since action research is primarily teacher-led, the researcher chose their own school for the study. The technology infrastructure of the school was the second determining factor that influenced the selection of the school as a research setting. This has a relationship with the study's objective, which was to examine how to effectively integrate technology into the science teaching and learning process. The researcher had unrestricted access to the school's technology infrastructure because he was already a member of the teaching staff in the research setting.

Before finalizing the research setting, the advisor recommended conducting a brief investigation to confirm whether the school possessed the essential technological infrastructure to support the study. Subsequent to this investigation, it was determined that the school was well-equipped with various technological tools, including computers, interactive whiteboards, projectors, internet connectivity, and a range of virtual learning environments such as ClassDojo, Google Classroom, JSTOR, Twinkl, Macmillan Education, Cambridge Go, Edmodo, eduforfun, etc. The availability of these technological tools was considered sufficient for conducting the study on integrating technological tools into the science teaching-learning process in that setting.

After deciding on the research setting and the participants, a petition was sent to the school through the Anadolu University Rectorate to seek permission to carry out the study. Moreover, permissions were sent to Anadolu University's ethics committee and the Ministry of National Education. The data collection process commenced after receiving positive feedback from these units. The permission letters obtained from the Anadolu University Social and Human Scientific Research and Publication Ethics Board and the Ministry of National Education are presented in Appendices 2 and 3, respectively.

In qualitative research, it's crucial to paint a vivid picture of the research setting. This not only helps in understanding how data about the research subject was collected but also provides a context for the unfolding implementation. Therefore, a detailed description of the research environment has been provided to offer insights into where and how the implementation transpired. The research was conducted at International Gokkusagi Schools, a private educational institution located in Ankara. Catering to students from pre-school to grade 12, the school is housed in an eight-story building. The building is segmented into three main sections: elementary school, middle school, and high school. Operating as an international school, it offers both the Ministry of National Education curriculum for national students and the Cambridge curriculum for international students. School sessions are held on weekdays, running from 8:30 a.m. to 4:15 p.m.

The right-side hallway of the second floor of the school's building is a designated area that houses various classrooms for students in the middle school grades. Among the classrooms in this section, there is one particular classroom—7th grade—where this study was conducted.

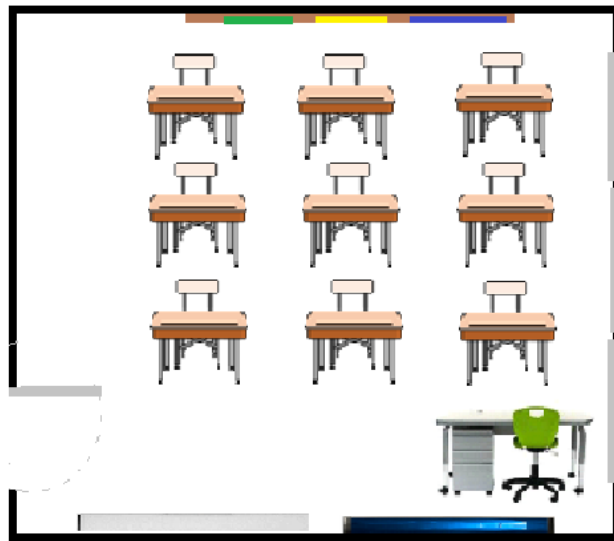


Figure 4. *Seating arrangement before a cooperative science lesson integrated with technology.*

As depicted in Figure 4, the classroom was rectangular in shape, with dimensions of about 8 meters wide and 10 meters long. The floor of the classroom was covered with grey square tiles, while the walls were painted white. There were three large transparent glass windows on one side of the classroom, which allowed an ample amount of natural light into the classroom. The other side of the classroom, on the other hand, had a sizeable wooden and metallic door with a square glass pane. Posters from teachers' and students' work are also displayed on the empty wall next to the door.

There were nine smooth, rectangular wooden student desks with metal legs, neatly and orderly arranged in three rows in the centre of the classroom, facing the smartboard and whiteboard mounted on the wall. This seating arrangement depicted how students sat in a traditional classroom, where they were arranged in rows facing the smartboard and directly behind one another. Figure 6 illustrates this seating layout. There was also a large white wooden teacher's table positioned on the far-right side of the classroom, with a comfortable chair behind it facing the student desks. The instructor, whose lesson it is, sets up their materials on the teacher's vacant table.

The whiteboard and smartboard were mounted side by side on the front wall. The whiteboard was a traditional white surface for writing with markers, while the smartboard was an interactive display that was used for multimedia presentations. At the back of the classroom, there was a rectangular wooden noticeboard mounted on the wall. It was

covered in colourful papers and posters, displaying announcements, upcoming events, and student achievements.

The seating arrangement employed in the delivery of science lessons integrated with technological tools was designed to align with the cooperative learning approach. This approach, rooted in social constructivist learning strategies, formed the theoretical basis for the study. This seating arrangement is depicted in Figure 5.

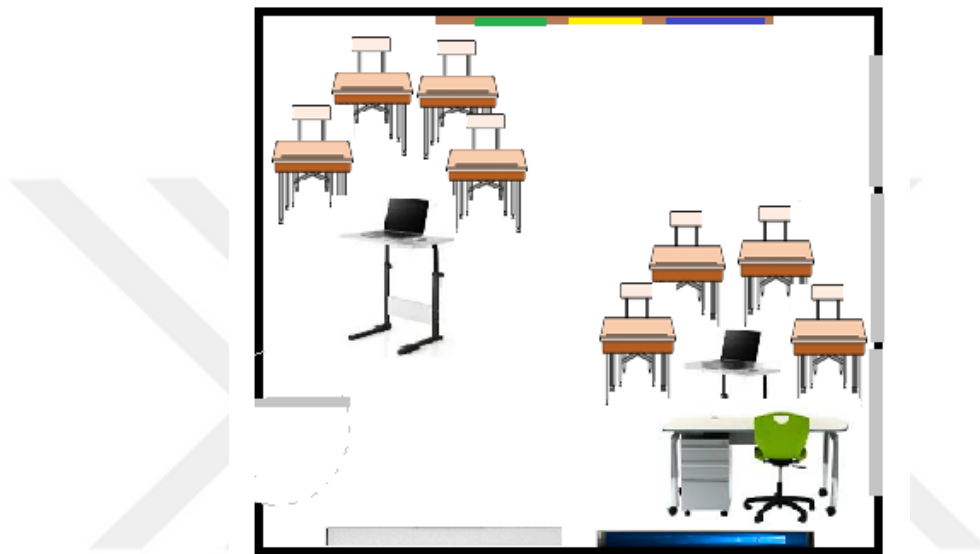


Figure 5. *Seating arrangement during a cooperative science lesson integrated with technology.*

As shown in Figure 5, before the science lessons integrated with various technological tools, the seating was rearranged from traditional rows into two groups of four desks each, creating a cooperative seating arrangement. Additionally, each group had a laptop set up in front of them for use during the lesson. Throughout the implementation, the students were grouped, provided with the necessary technological tools, and engaged in collaborative work.

2.5. Participants and the Researcher

2.5.1. Participants

The participants for this study were selected using the purposeful sampling technique, a sampling technique used in qualitative studies. In this kind of sampling technique, the researcher selects participants and research settings because they can

deliberately contribute to comprehending the study's main phenomena and research problem (Creswell, 2013). A study's sample must be specified while it is being planned, as Robson (2011) emphasizes. The necessity of adequately responding to the research questions must be its primary goal.

Kusi (2012) expressed that manageability is a criterion that affects the decision on a suitable sample size for studies that fall within the interpretative research framework. He further pointed out that the objective of this research—qualitative research—is to investigate a phenomenon for a deeper understanding; therefore, choosing a sample size is essential to achieving this goal.

For the purposes of this study, a total of eight 7th grade students were selected as participants. The participants were split between male and female students, with four females and four males. These particular students were selected for the study because it was thought that they were at an important stage in their cognitive development, thus the formal operational stage, typically around 12 years and above, making them well-suited to offer insightful information on how effectively integrating technology into science instruction affects their learning. The cognitive development theory postulated by Piaget, which contends that children's cognitive capacities grow in discrete stages, had an impact on this choice (Papalia & Feldman, 2011). This indicates that different teaching strategies, including integrating technology in the classroom, may be more or less effective with students depending on their developmental stage.

One of the features that made the 7th graders suitable participants to collaborate on the study is that they are in an age group that is generally technologically savvy and digital natives, which is an excellent quality that gives them some level of familiarity with emerging technologies and enables them to adapt to new digital technologies and platforms more readily than younger or older students. Additionally, a wide range of topics in the 7th grade science curriculum can be effectively instructed through a number of digital technologies, which made the participants and the grade level the best candidates and levels to collaborate in the study.

These students were observed and instructed in science lessons that incorporated technology into the instructional process. The effectiveness of technology integration in science instruction was investigated by carefully observing the students throughout the study. In addition to being observed, questionnaires, reflection journals, and interviews were employed to explore the students' perceptions and views regarding the integration

of technology into science instruction. These interviews were undertaken to uncover more about the experiences of the students and how the use of technology impacted their learning of key science concepts. Table 1 displays the students' demographic characteristics. This information is important since it gives a thorough insight into the participants in the study.

Table 1. *Demographic characteristics of participants*

Name	Gender	Age
Student 1	Female	14
Student 2	Female	13
Student 3	Female	14
Student 4	Male	13
Student 5	Male	13
Student 6	Male	14
Student 7	Female	14
Student 8	Male	13

As shown in Table 1, eight students participated in the study, with an equal gender distribution of four males and four females. These students, ranging in age from 13 to 14 years, collaborated in the study. The balanced mix of genders and close age range provided a diverse yet cohesive group for the study.

2.5.2. The role of the researcher

Unlike in quantitative research, where the researcher acts as an outsider, collecting data and performing statistical analysis, this is not the case with qualitative research. The researcher is actively involved in the research environment with other participants in qualitative research. As a result, the researcher's abilities, principles, and worldview are crucial to the success of validity and reliability studies (Karadağ, 2010). Karadağ (2010) opines that there is a plethora of reasons why the researcher's physical presence is important during a qualitative study. One of these is the relationship that develops between the participants and the researcher. In such a scenario, the participants are more likely to open up and provide honest remarks when they have a cordial relationship that fosters trust and comfort with the researcher. Additionally, Karadağ (2010) expressed that by being physically present in the research environment, the researcher is able to comprehend the general dynamics and aspects of the environment, which helps to make sense of the participant's responses and viewpoints. Finally, by being physically present in the research setting, the researcher is able to observe the participants' gestures,

countenance, and implicit inklings that are impossible to pick up on in a remote setting, which can help the researcher gather delicate information (Karadağ, 2010).

In action research, the researcher actively takes part in the research process, as highlighted by Hendricks (2006). Those engaging in action research, often teachers, play a key role in shaping the classroom environment, given their professional responsibilities and awareness of the social dynamics within the class (Altrichter et al., 1993). This involvement can either be initiated by the practitioner independently or collaboratively with a researcher, as discussed by Yıldırım and Şimşek (2005). In this study, the researcher collected and analyzed data before, during, and after the implementation and acted as the implementer of the technological tools integrated into the science lesson during the implementation stage. Additionally, the researcher took part in the validity committee meetings, where the collected data were discussed and action plans were developed. Within the context of this study, the researcher assumed the roles of research practitioner and science teacher.

The researcher possesses nearly four years of experience as a science teacher, with close to two of these years spent teaching science in the current research setting. As a dedicated educator, he is committed to enhancing his teaching practices by exploring the effective integration of technological tools into science lessons and assessing how these tools contribute to students' understanding and enjoyment of the subject.

In this study, the researcher assumed a dual role as both the researcher and the students' science teacher. This dual role holds significant importance, as it enables participants to open up to the researcher, facilitates the researcher's understanding of the general dynamics and aspects of the research setting, and allows for the observation of participants' gestures, expressions, and implicit cues that may not be discernible in a remote setting. This close interaction aids in gathering nuanced and delicate information for the study. This dual role is especially important for practical action as a teacher-researcher. However, the teacher-researcher also acts as a participant-observer, which might introduce researcher biases. Various precautions were taken to minimize these biases as much as possible, including data triangulation, time triangulation, researcher triangulation, detailed descriptions, and validity committee meetings.

Additionally, the researcher has substantial proficiency in qualitative research, bolstered by his background, including an action research project conducted during his undergraduate studies. Moreover, in his current studies in the Department of Curriculum

and Instruction at Anadolu University, he has undertaken courses such as "Scientific Research and Report Writing," "Qualitative Research Methods," and "Research Methods in Educational Sciences." These courses, along with the researcher's experiences and exposures, have made him competent in this research field.

2.6. Data Collection Instruments

According to Gay, Mills, and Airasian (2016), the type of data collected for an action research study is largely determined by the nature of the problem. The problem that this study aimed to investigate was how to effectively integrate technology into the science teaching and learning process. In order to understand and consequently remedy the problem, many aspects of inquiry were investigated throughout the science lesson in order to obtain a more nuanced understanding of how to effectively integrate technology into the science teaching and learning process. Within the framework of this study, observation protocols, field notes, semi-structured interviews, questionnaires, reflective journals, lesson plans, and validity committee meeting records were the instruments that were employed to collect data. The use of these data collection instruments was consistent with Creswell's (2014) claim that the use of complementary approaches shows inconsistencies since a single method can neither be sufficient nor reliable. Many sources of data are certainly appropriate as long as they are collected ethically, practically, and in a way that advances understanding of the phenomenon being studied (Gay, Mills, and Airasian, 2016). Moreover, using numerous sources of data will provide the necessary triangulation (Yeasmin and Rahman, 2012).

As the action research method was employed in this study, and considering that action research is a systematic process, an action plan was formulated prior to the implementation and subsequent data collection. Collaboratively with the validity committee members, the researcher discussed the selection of data collection instruments and their use in the implementation stages. Furthermore, given that action research unfolds in a spiral cycle, data collection and macro-analysis of the data were carried out concurrently.

Figure 6 illustrates the data sources for the study, which primarily involved three key contributors: validity committee members, the researcher, and students. Data collected from validity committee members encompassed records from the proceedings of committee meetings conducted before each implementation. These meetings focused

on reviewing and discussing the proposed lesson plans to ensure their appropriateness. The emphasis was placed on examining instructional objectives, the duration of the lesson, the instructional process, and the evaluation tools to be employed in assessing students' comprehension and the achievement of instructional objectives.

Given that the study centered on exploring effective ways to integrate technological tools into science teaching and learning, the validity committee members thoroughly evaluated the technological tools incorporated into the lessons. This scrutiny aimed to confirm that the chosen tools met established standards, were suitable for the students' academic level, were capable of contributing to the attainment of instructional objectives, and were capable of providing an enjoyable learning experience.

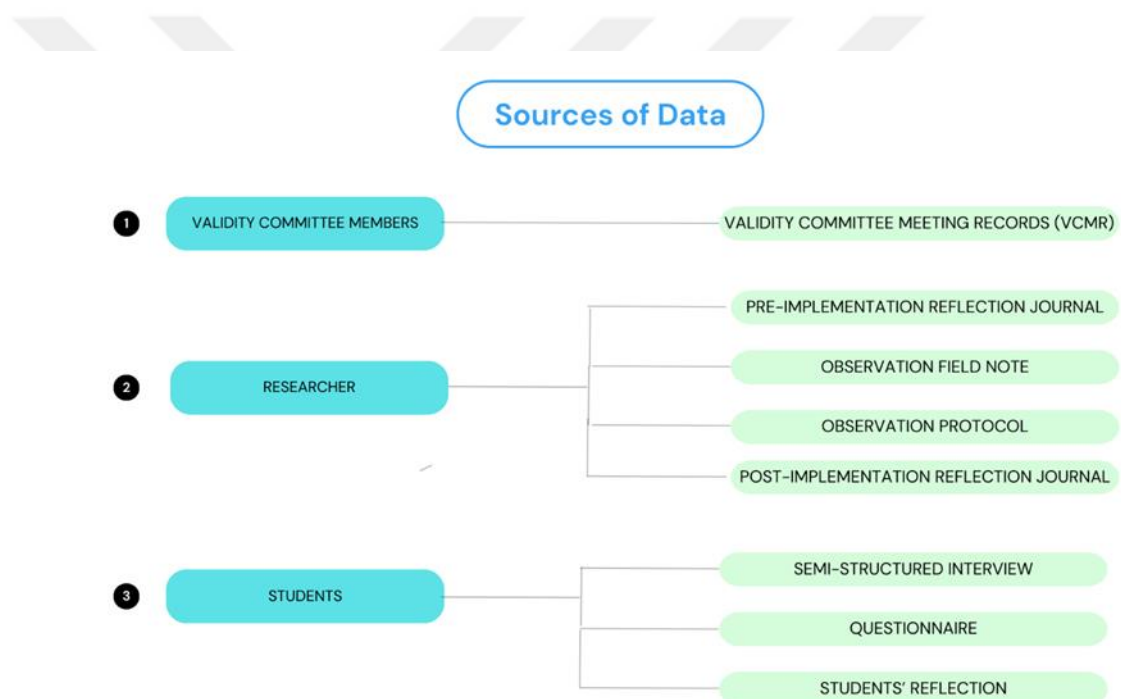


Figure 6. *Sources of data*

As shown in Figure 6, data were collected from three sources: validity committee members, the practitioner researcher, and the students. The data from the validity committee members included meeting records. The data from the practitioner researcher included a pre-implementation reflection journal, observation field notes, an observation protocol, and a post-implementation reflection journal. Finally, the data from the students included a focus group semi-structured interview, a questionnaire, and an exit ticket in

the form of a reflection journal. Additionally, the same data collection instruments were utilized consistently throughout the three-week implementation.

Furthermore, data were collected before, during, and after the implementation. Figure 7 illustrates the phases of data collection throughout the study, which included pre-implementation, implementation, and post-implementation.

As shown in Figure 7, before the implementation, the data collected included records from the validity committee meetings regarding the implementation and the researcher's pre-implementation reflection journal. During the implementation, the researcher documented observation field notes and used an observation protocol based on their observations of the implementation. Finally, at the end of the implementation, information was gathered from the students through semi-structured interviews, questionnaires, and students' exit tickets in the form of reflection journals. The researcher also composed a post-implementation reflection journal, sharing personal views on how the implementation unfolded after its completion.

The researcher, occupying a central role in the entire research process, served as the primary data source for the study. Various types of data were generated by the researcher, encompassing pre-implementation reflection journals, observation field notes, observation protocols, and post-implementation reflection journals. Additionally, the researcher provided data in the form of the lesson plan and the technology integration timeline.

Within the context of this study, the data collection tools employed to gather information from the validity committee members, the researcher, and the students comprised the following:

- Validity committee meeting records
- Researcher's and students' reflection journals
- Observation field notes and protocols
- Semi-structured interviews
- Questionnaires
- Lesson plans

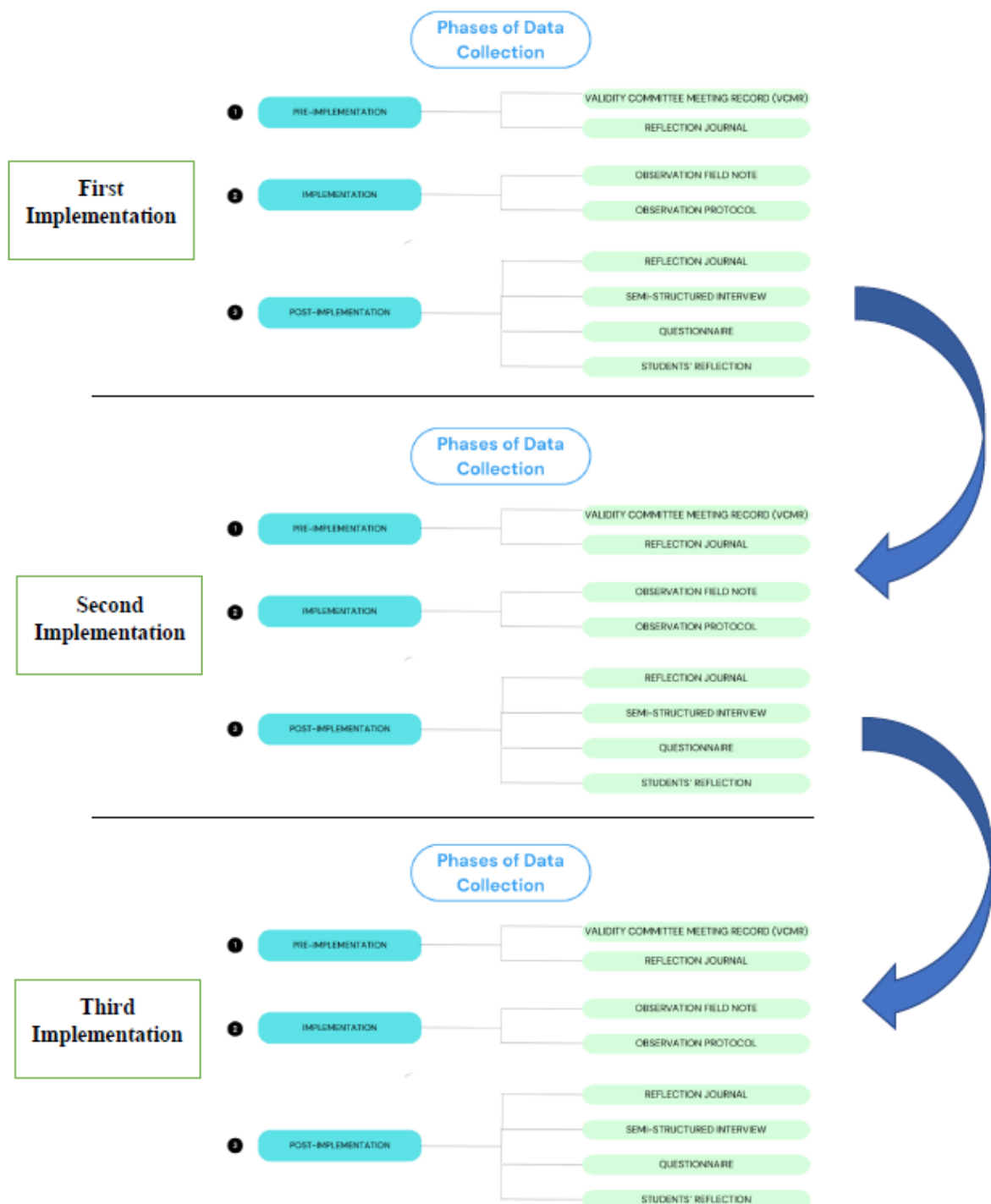


Figure 7. *Phases of data collection*

2.6.1. Validity Committee Meeting Records

The validity committee consisted of four members, with the advisor and co-advisor of the researcher serving as two of its members. The other two members included the

practitioner researcher and a field expert, who happened to be a science teacher. The validity committee convened to conduct meetings centered around the action plans intended for implementation. Additionally, the committee played a crucial role in ensuring the validity and reliability of the findings derived from the macroanalyses conducted throughout the implementation process.

Moreover, within the validity committee meetings, a thorough examination of the lesson plans and the technological tools slated for implementation in the lesson was conducted to assess their appropriateness. One of the primary objectives behind establishing the validity committee was to proactively address any issues that might arise during the implementation phase. Throughout the implementation, any challenges that surfaced were deliberated upon during validity committee meetings, and concerted efforts were made to devise solutions for the problems.

These solutions were subsequently implemented in the ensuing phases to gauge their effectiveness in addressing the identified problems. If a solution proved successful in remedying the issue, it was deemed satisfactory. However, if a problem persisted, the validity committee members engaged in further discussions during their meetings to explore new solutions. These newly proposed solutions were then implemented in subsequent phases, and this iterative process continued until a viable resolution was identified for the problem at hand.

A total of four validity committee meetings were conducted on Thursdays, from November 16th, 2023, to December 3rd, 2023. These meetings took place on the Zoom platform and were both video-recorded and documented by the researcher. Subsequent to each meeting, the researcher reviewed the recorded Zoom sessions, documenting the problems identified and resolved during the discussions in the validity committee meeting records.

Furthermore, during each validity committee meeting, quantitative data gathered from students' questionnaires regarding encountered problems, the impact of technology on understanding, and the overall enjoyment of the lesson with technology were presented. Discussions also included an examination of the technological tools integrated into the lesson and their methods of integration. Finally, feedback regarding the proposed solutions to previous problems were discussed, regardless of whether the challenges were successfully resolved or not. A recorded validity committee meeting is presented in

Appendix 4. Table 2 presents the dates, times, and durations of the validity committee meetings.

Table 2. *Validity Committee Meetings Dates, Times, and Durations.*

Validity Committee Meetings	Date	Time	Duration
1	16 th November, 2023	8:00 pm – 10:40 pm	160 minutes
2	23 rd November, 2023	8:00 pm – 9:30 pm	90 minutes
3	30 th November, 2023	8:30 pm – 10:00 pm	90 minutes
4	4 th December, 2023	8:30 pm – 10:00 pm	90 minutes

As shown in Table 2, a total of four validity committee meetings were held throughout the study. The first meeting took place on November 16, 2023, from 8:00 PM to 10:40 PM, lasting 160 minutes. The second meeting was held on November 23, 2023, from 8:00 PM to 9:30 PM, lasting 90 minutes. The third and fourth meetings were held on November 30, 2023, and December 4, 2023, respectively. Both meetings were conducted from 8:30 PM to 10:00 PM, each lasting 90 minutes.

2.6.2. Researcher's and students' reflection journals

A reflective journal, a qualitative data collection instrument, was employed by both the researcher and the students to document events that unfolded during the implementation. As per Holly (1989), reflective journal writing serves as a potent tool for educators to delve into their practices, capture the unfolding dynamics of classroom life, and reflect on past experiences, life histories, and the socio-historical and educational contexts shaping the present. The utilization of a reflective journal for data collection offers numerous advantages. One of its advantages is its ability to assist the researcher in recalling information at a later time, serving as a comprehensive record for review (Holly, 1989). Additionally, it provides individuals with a means to perceive themselves, their emotions, and their experiences in novel ways. Moreover, it serves as a platform for reflecting on professional accomplishments and challenges, exploring alternatives, and enhancing the visibility of teaching knowledge (Evans and Maloney, 1998: 29).

In this study, the researcher maintained two reflection journals: a pre-implementation reflection journal and a post-implementation reflection journal for three action research cycles. Thus, six reflection journals were written in total by the researcher.

These journals served as platforms for the researcher to document personal feelings, thoughts, evaluations, and comments concerning the implementation process. Simultaneously, students also utilized reflection diaries to capture their perspectives during the implementation. The students' reflection journals, compiled after each implementation, placed emphasis on the types of technological tools integrated into the lesson, their impact on understanding the lesson, the challenges encountered due to these tools, the contribution of technological tools to their enjoyment of the lesson, and their overall perspective on the integration of technological tools into science lessons.

In the pre-implementation reflection journal, the researcher engaged in a personal reflection, articulating thoughts about the forthcoming implementation. Moreover, the researcher elaborated on the following questions within the pre-implementation reflection journal:

1. What is the purpose of the implementation?
2. What kinds of technological tools are going to be integrated into the lesson?
3. What are the reasons for selecting these technological tools?
4. What are the sources of these technological tools?
5. How are the technological tools integrated into the lesson?
6. In what phases of the lesson are the technological tools going to be integrated?
7. How do you plan to solicit information from the students during the implementation?
8. What problems do you anticipate might disrupt the implementation?

The researcher extensively addressed these questions prior to each and every implementation. This pre-implementation reflection journal also served as a blueprint and guide, providing direction for the researcher throughout the implementation process. A pre-implementation reflection journal is presented in Appendix 5.

At the end of the implementation, the researcher also documented a post-implementation reflection journal to discuss personal perspectives on how the implementation unfolded. In this post-implementation reflection journal, the researcher elaborated on the following questions:

1. What was the purpose of the implementation?
2. What technological tools were integrated during the implementation?
3. How were the technological tools integrated?
4. What technological tools were integrated, and at what phase?

5. How did the students interact with the integrated technological tools?
6. How was feedback solicited from the students regarding the implementation?
7. What was the students' feedback about the implementation?
8. Did everything unfold according to plan?
9. What problems were encountered?
10. How were these problems resolved?
11. Was there anything that could have been done differently?
12. How was the class time managed?

This post-implementation reflection journal served as a retrospective tool for the researcher to assess whether the objectives for which the implementation was carried out were achieved. It also served as a guide for subsequent implementations. A post-implementation reflection journal is presented in Appendix 6.

The researcher wrote a total of six reflection journals, comprising pre-implementation reflections preceding the implementations and post-implementation reflections following the three-week implementation period. Table 3 delineates the dates on which the researcher composed the pre-implementation and post-implementation reflection journals.

Table 3. *Pre- and Post-Implementation Reflection Journal Dates*

Number of reflection journals	Pre-implementation reflection journal	Post-implementation reflection journal
1	19 th November, 2023	20 th November, 2023
2	26 th November, 2023	27 th November, 2023
3	3 rd December, 2023	4 th December, 2023

As depicted in Table 3, a total of six reflection journals were documented by the researcher throughout the study. These journals were evenly divided between pre-implementation and post-implementation reflections. The first pre-implementation reflection journal was written on November 19, 2023, followed by the first post-implementation reflection journal on November 20, 2023. Similarly, the second pre-implementation and post-implementation reflection journals were recorded on November 26, 2023, and November 27, 2023, respectively. Lastly, the final pre-implementation and post-implementation reflection journals were documented on December 3, 2023, and December 4, 2023, respectively.

The students also utilized exit tickets in the form of reflection diaries to capture their perspectives during the implementation. They collectively wrote eighteen exit tickets, with six completed at the end of each implementation over three weeks. The students' exit tickets, submitted at the end of each lesson, focused on the technological tools integrated into the lesson, their impact on comprehension, challenges encountered, the influence of these tools on their engagement, and their overall perspective on integrating technology into science lessons. The students wrote their exit tickets on November 20th, 2023, November 27th, 2023, and December 4th, 2023, corresponding to the first, second, and third reflection journals, respectively. A sample of a student's exit ticket is provided in Appendix 7.

2.6.3. Observation field notes and protocols

Observation is one of the key tools for collecting data in qualitative research. An activity or process of attentively observing or monitoring, or a statement made in response to what one has seen, heard, or noted, constitutes observation, a non-test approach (Eshun & Effrim, 2009). Angrosino (2007) defined observation as the act of noting an occurrence in the field using the observer's five senses, frequently while using an instrument, and recording it for scientific purposes. The observations are based on the objectives and questions of the study. The researcher may observe himself or herself during the observation, as well as the environment, participants, activities, interactions, and conversations. The five senses—sight, hearing, touch, smell, and taste—are used. Given that it is impossible to record everything that is observed, it is best to begin the observation with a broad perspective before focusing on specific research questions (Creswell, 2013). The goal of observation is to understand individuals' experiences in the natural world without altering or affecting them (Gay, Mills, & Airasian, 2012). In the quest to explore the disposition of students and how their learning of science is impacted by integrating technology into the instruction, they were observed in order to solicit this information. According to Gay, Mills, and Airasian (2012), observation is the most appropriate and efficient method for gathering data for some research problems.

According to Merriam and Tisdell (2016), an observer can adopt several stances when gathering data. These stances include full participant, where the investigator is a part of the group being watched, and spectator. Gold's (1958), cited in Merriam and Tisdell (2016), classic typology offers a spectrum of four possible stances. These are

complete participant, participant as observer, observer as participant, and complete observer. Participant-as-observer, a type of observation, was employed within this study. In this observation technique, the researcher served as both a participant and an observer. Schensul and LeCompte (2013), cited in Merriam and Tisdell (2016), refer to this as “a data collection technique that requires the researcher to be present at, involved in, and actually recording the routine daily activities with people in the field setting” (p. 83), while maintaining an active participant role. The researcher was instructing the science lesson integrated with technological tools while also observing the students in the instructional setting. The participant role was more salient than the researcher role. This helped the researcher gain insider views and subjective data.

As a participant, the researcher involved students in science teaching and learning to gain first-hand experience of how students learn when various technological tools were integrated into the instructional process. The researcher, together with the students, arranged the learning environment and ensured that all the resources and technologies needed for the lesson were present. Simultaneously, the researcher was observing the students’ interactions with each other and with the technological tools. Furthermore, the researcher was in constant interaction with the students, just like a participant in the learning activities.

On the other hand, as an observer, the researcher took notes, observed the teaching-learning process, observed their demeanour, and collected other types of data to gain a more comprehensive understanding of the classroom environment. How the students handled the technology in the lesson, the challenges they faced, and how they remedied those challenges were observed and recorded as well. Furthermore, in the participant-as-observer observation technique, the researcher’s knowledge of the participants’ ways may well be extensive. Similarly, existing relationships with individuals can short-circuit a lengthy process of developing trust (Robson & McCartan, 2016). The observation protocol was also utilized by the researcher to record observations made during the implementation. The observation protocol comprised a structured set of guidelines and procedures to systematically and objectively document specific behaviors, events, and/or phenomena observed during the implementation. The observation protocol also included detailed, chronological notes about what the researcher saw and heard, what occurred, and the physical setting. Additionally, it encompassed concurrent notes about the

observer's thoughts, personal reactions, and experiences. A sample of the observation protocol is presented in Appendix 8.

The observation field note was another valuable piece of data sourced from the researcher. The observation field note was written by the researcher immediately after each implementation. There was no specific format followed in writing the observation field note. The observation field note essentially contains all the observations made by the researcher from the beginning of the implementation to the end of it. Information regarding the seating arrangement, the activities carried out in the classroom, students' interaction with their colleagues and technological tools, problems encountered, how the problems were resolved, students' demeanour, and students' behavior, among other things, were captured in the observation field note. A sample of the observation field note is presented in Appendix 9.

The criteria observed during the implementation included which and how technological tools were integrated, students' interaction with technological tools, students' participation in the lesson, problems encountered, and how these problems were remedied. Finally, it addressed how the technological tools affected the classroom environment and order.

2.6.4. Semi-structured interviews

According to Gay, Mills, and Airasian (2012), an interview is a deliberate conversation in which one party seeks information from another. Interviewing is a highly effective method for gathering information about participants' actual experiences (Van den Berg, 2005). DeMarrais (2004), cited in Merriam and Tisdell (2016), defines a research interview as "a process in which a researcher and participant engage in a conversation focused on questions related to a research study" (p. 55). According to Gay, Mills, and Airasian (2012), conducting interviews enables researchers to get crucial information that observation alone is unable to provide. Interviewing becomes necessary when behavior, feelings, or how people interpret the world around them cannot be directly observed (Merriam & Tisdell, 2016).

A semi-structured interview, a type of interview, was employed to elicit information from participants following their science lessons integrated with various technological tools. The interview questions were formulated by the researcher and his advisors. These semi-structured interview questions were comprised of open-ended questions. Pilot

interviews were conducted with student volunteers. Based on expert opinions obtained after the pilot interviews, it was determined that the interview form was suitable and could be utilized for collecting research data.

A semi-structured focus group interview was carried out with students after the implementation to gather their perspectives on the science lesson integrated with technological tools. Instead of individual interviews, the validity committee decided to conduct focus group interviews. Therefore, while the pilot study was conducted individually, all the questions were revised to suit a focus group setting. The reason for opting for this type of interview was to promote group dynamics and interactions among students, facilitating the exploration of diverse perspectives and shared experiences. Furthermore, using the focus group interview allowed all students to be interviewed simultaneously, saving the researcher a significant amount of time. Throughout the semi-structured interview, participants were asked about what they learned, the integrated technological tools, the methods employed to integrate these tools, the impact of technological tools on their understanding of the lesson, their attitudes towards these tools, challenges encountered, and their resolution, grades, and performance influenced by the integrated technological tools, as well as their overall thoughts on the integration of technological tools into the science lesson.

During the interview session, a digital audio recording device was utilized to record the interviews. Complete confidentiality and anonymity were assured to all the students. All the students willingly engaged in the interview session, which lasted approximately 15 minutes. Each interview session was promptly transcribed verbatim. A transcribed copy of the interview was provided to the students for their review to ensure accuracy, identify any inconsistencies, and include additional comments if necessary. Once it was confirmed that the transcribed interview accurately reflected the ideas, notions, and views of the interviewees, the data was prepared for macro-analysis. An interview form is presented in Appendix 10. Table 4 illustrates the interview numbers, the dates on which the interviews were conducted, and the duration of each interview.

Table 4. *Interview Number, Date, and Duration*

Interview Number	Date	Duration (minutes)
1	20 th November, 2023	15.18
2	27 th November, 2023	14.76
3	4 th December, 2023	15.35

As shown in Table 4, three semi-structured focus group interviews were conducted with the students after the science lessons integrated with various technological tools. The first interview was conducted on November 20, 2023, and lasted for 15.18 minutes. The second interview took place on November 27, 2023, and lasted for 14.76 minutes. Finally, the last interview was conducted on December 4, 2023, and lasted for 15.35 minutes.

2.6.5. Questionnaires

A questionnaire is basically a set of written survey questions designed for a specific group of participants to answer (Gay, Mills, and Airasian, 2012). In the context of this study, a questionnaire was utilized to gather data from students regarding the science lesson integrated with technology post-implementation.

During the first validity committee meeting, the third committee member suggested developing a data collection instrument to gather data from the students, as much of the data seemed to be coming from the researcher. The committee member recommended that the instrument include a rating scale for students to assess their understanding and the problems they encountered. Additionally, it should provide space for students to express themselves in writing. The second committee member also suggested adding a section to evaluate students' enjoyment. These suggestions led to the development of the questionnaire utilized in this study.

The developed questionnaire comprised three main questions focused on the problems encountered, technology's contribution to understanding, and enjoyment of the lesson with technology. The students provided their thoughts under these main headings. Meanwhile, with the rating scale, students assigned ratings to these three main aspects on a scale of 1–10. This questionnaire form is presented in Appendix 11.

Prior to the science lesson integrated with various technological tools, the students' seating arrangement was changed from traditional rows to cooperative groups. After the lesson, the seating was transitioned back to traditional rows, and the students were then administered questionnaires to complete individually. This process was repeated after

each lesson throughout the three-week implementation period. Consequently, the students filled out the questionnaire three times—once after each implementation.

2.6.6. Lesson plans

The lesson plans crafted prior to implementation served as a comprehensive data source regarding the delivery of science lessons and the integration of technology and other resources. The lesson plans delineated the segments of the lesson where technological tools were incorporated. A total of three distinct 80-minute lesson plans were developed for the three-week implementation period. Each lesson plan comprised five sections, encompassing crucial details such as grade, unit, topic, date, and duration. Furthermore, the plans outlined learning objectives, technology integration tools, teaching and learning context, and allocated resources. Provisions were also made for the technological tools to be employed during the assessment stage of the lesson.

Prior to implementation, a lesson plan was developed based on the upcoming unit to be covered in class. This was done to ensure a seamless continuation from regular lessons to the implementation of the study. The lesson objectives and content were derived from the class's primary resource, the "Cambridge Lower Secondary Science Stage 8 2nd Edition" book. Additionally, technological tools were selected and integrated into the lesson based on its instructional objectives.

During the validity meetings held before implementation, the lesson plan was presented to the committee members. All the technological tools were demonstrated to them. If the members deemed the technological tools appropriate and capable of helping achieve the instructional objectives, then the lesson plan was approved for implementation. There were instances where committee members recommended using different technological tools and alternative modes of assessment. Ultimately, the validity committee had to give approval before the lesson plan could be implemented.

During post-implementation validity committee meetings, the problems encountered during the implementation were discussed with the committee members, and solutions were sought. These solutions were then formulated into action plans, which were integrated into subsequent lesson plans to address the identified problems. This process was repeated throughout the three-week implementation, and it was through these iterative cycles that the lesson plans utilized in this study were developed. The developed lesson plans are presented in Appendix 12.

2.7. Data Analysis and Interpretation

In qualitative research, data analysis involves preparing and organizing the data for analysis, condensing themes from the data through the process of coding, refining the codes, and ultimately presenting the data in figures, tables, or discussions (Creswell, 2013). The primary purpose of analyzing data is to derive meaning from it (Merriam, 2009).

In action research, as outlined by Yıldırım and Şimşek (2005), data analysis occurs simultaneously with data collection, offering insights into the type and format of additional data that needs to be collected. The analysis of the gathered data provides an understanding of the application or process under investigation. The researcher incorporates remarks and offers recommendations concerning the research problem while reporting and analyzing the data within the context of the existing literature.

Both qualitative and quantitative data were gathered in the context of this study. The quantitative data collected consisted of the questionnaire, which incorporated a scale. Qualitative data included the researcher's and students' reflection journals, observation field notes and protocols, semi-structured interviews, and records from validity committee meetings and the lesson plans. The qualitative data were synthesized into common themes based on the research questions and interpreted alongside the findings from the quantitative data analysis. The questionnaire data were analyzed using graphs for the scaled items and themes for the open-ended questions. Given Johnson's (2005) assertion that the primary aim of action research is to comprehend occurrences within the research context, it was considered essential in this study to provide a detailed description of the data collected through descriptive analysis. This approach aimed to gain insights into the experiences of the participants impacted by the action research process, which focused on integrating technological tools into the science teaching and learning process. Therefore, each week of implementation was described in detail.

2.7.1. Quantitative data analysis

The students were administered a questionnaire to gather data to address the research questions: "What technology can be used to improve students' understanding of key science concepts?" and "What problems are encountered in the process of integrating technology into science lessons, and what are their solutions?". The questionnaire's quantitative parts comprised a scaled list of three items, prompting students to rate, on a

scale of 1–10, the problems encountered due to the integration of technology into science lessons, technology's impact on understanding, and enjoyment of lessons with technology. Frequencies and means were calculated for each of these themes. The data from this session were analyzed within these three themes and presented through graphs for descriptive analyses. Additionally, as the questionnaire included unstructured items, which provided students with complete freedom in their responses, the students' responses were categorized into three main themes and analyzed descriptively.

2.7.2. Qualitative data analysis

A distinctive feature of action research is the simultaneous collection and analysis of data, known as macro-level analysis. Consequently, while still immersed in the research setting, the researcher gathered and analyzed data concurrently. Macro-level analysis involves examining the collected data from a higher-level perspective, focusing on identifying themes, patterns, and trends, and understanding the data beyond the students' immediate experiences. A comprehensive analysis of the data was conducted, emphasizing both the broader context and the details. Following the macro-analysis during the data collection phase, a more specific micro-analysis was performed. Micro-level data analysis entailed a closer scrutiny of the data, paying attention to subtleties and specifics. Unlike the structured and static nature of macro-level analyses, as noted by Strauss and Corbin (1998), micro-analysis is a flexible process that evolves with the detailed exploration of the data.

Throughout this study, within the three-week implementation period, the researcher conducted macro-level analyses to present immediate results and weekly data to the validity committee. During this process, the researcher reviewed all qualitative data from the week, noted any problems indicated or emerging from the data, attempted to understand the potential causes of these problems through a comprehensive review of the dataset and personal experience, and compiled a report summarizing macro-level analysis findings (with a primary focus on problems and emerging perspectives or ideas). This report included photos of the data, a sample lesson plan for the subsequent week, and decisions from previous committee meetings. Macro-level analysis results underwent review by the validity committee, as they also reviewed all data collected throughout the week.

After the completion of the three-week implementation process, inductive thematic analysis was employed, utilizing both deductive and inductive approaches as complementary data analysis techniques subsequent to macro-level analysis. Thematic analysis, a qualitative research method, systematically organizes and analyses complex datasets to uncover overarching themes that encapsulate the narratives present within the data (Dawadi, 2020). This process involves carefully reading and re-reading transcribed data to identify and categorize these themes (King, 2004; Rice & Ezzy, 1999).

The inductive technique involves developing categories from a detailed examination of the data, while the deductive method entails constructing categories based on research questions and existing theories (Altrichter et al., 2008). By employing both approaches, thematic frameworks were established, drawing from past knowledge gained from the implementation process while remaining open to emergent themes throughout the analysis (Altrichter et al., 2008). The data subjected to thematic analysis include researchers' and students' reflection journals, observation field notes and protocols, and records from validity meetings. Students' questionnaire responses were used to enrich the findings, presented as raw data alongside the students' perspectives. Lesson plans served as the primary implementation instruments for this action research, reflecting all decisions made throughout the process.

During the micro-level thematic analysis, the following steps were undertaken (Cresswell, 2009):

1. Data Organization and Preparation: The data from the students' semi-structured interviews were meticulously organized by transcribing them verbatim into Word documents. To ensure participant anonymity, the students' data were coded as Student 1, Student 2, and so forth.
2. Data Familiarization: All data were thoroughly read and re-read, and interview recordings were listened to multiple times to gain a general understanding of the information and reflect on its overall meaning.
3. Coding Process: The micro-data analysis commenced with a coding process where transcribed interviews were categorized and labelled with terms derived from the participants' actual language. This manual process did not involve the use of qualitative data analysis software.
4. Theme Generation: The coding process was utilized to generate themes for analysis. In cases where there were multiple pieces of information under a

theme, sub-themes were created. These themes, which emerged as major findings, formed the headings in the finding's sections of the study, showcasing diverse perspectives from the participants and supported by quotations and evidence.

5. Qualitative Narrative Description: Themes were described in qualitative narrative form, involving a chronological discussion of events and the micro-analysis of themes and sub-themes, interrelating them as they unfolded throughout the three-week implementation.
6. Theme Interpretation: The meaning of themes and sub-themes was interpreted based on the researchers' background and experiences, as well as the insights derived from reviewed literature and theories.

Throughout the implementation process, the minutes of the validity committee meetings were examined, and the action decisions made each week before and after every implementation were consistently documented. Post-implementation, these records were regularly compiled. The meeting recordings were utilized to articulate the rationales behind the action decisions and to substantiate them with direct quotations.

The observation field notes and observation protocols underwent descriptive analysis. Themes and subthemes were deduced from the observation field notes, and direct quotes were extracted and interpreted based on their analysis. The observation protocols were inherently composed of pre-established protocols, serving as themes, under which the observations were analyzed. Similar to the observation field notes, direct quotations were extracted from the observation protocols during the process of descriptive analysis.

Lastly, both the researcher's and students' reflection journals underwent thematic analysis. The recurrent concepts prevalent in the journals were identified and transformed into themes and subthemes. Furthermore, the overarching topics addressed in the reflection journals contributed to the formation of these themes and subthemes. Throughout the analysis of these themes, direct quotations were extracted from the reflection journals and interpreted descriptively.

2.8. Validity and Reliability Studies

Whatever the nature of the research, validity and reliability are issues that can be addressed by paying close attention to how a study is conceptualized, how data are

gathered, processed, and interpreted, as well as how the results are communicated (Merriam and Tisdell, 2016). Criteria for effective action research have been described using the words such as validity, trustworthiness, credibility, and soundness. Researchers who are more positivist have a tendency to value validity more (Campbell & Stanley, 1963), whereas those who are more naturalistic value trustworthiness more (Lincoln & Guba, 1985).

Expert opinions and perspectives play a crucial role in action research, emphasizing that the knowledge, skills, and experiences of a trusted researcher contribute depth to the research (Baumfield et al., 2008). In the context of this study, the validity committee members conducted regular meetings before implementations to assess the technological tools slated for integration, review the lesson plan, and address solutions to issues from previous implementations. Moreover, they formulated action plans based on implementation findings. The collective roles fulfilled by the validity committee members significantly enhance the validity and reliability of the entire study, particularly in terms of data collection and analysis.

Çardak's (2012) studies have significantly influenced the determination of these roles within the action research process. In the context of this study, the validity committee members undertook the following roles:

- Participated in the review of implementation findings through macro-analyses, identifying and addressing emerging issues during the process.
- Engaged in weekly validity committee meetings.
- Proposed solutions for issues arising during the implementations.
- Provided guidance to the researcher throughout the study.
- Assessed the appropriateness of technological tools at the students' level.
- Recommended the most suitable technological tools for integration into the lesson.
- Assisted the researcher in the development of technological tools, such as the 3D simulation integrated into the lesson.
- Reviewed the lesson plan to ensure its suitability and the inclusion of provisions for technology integration and lesson evaluation.
- Formulated action plans for subsequent implementations.
- Participated in the validity and reliability assessments of findings obtained from the micro-analysis conducted after the implementation.

Furthermore, detailed meeting proceedings were documented. These written records were provided to the validity committee members before each meeting. The committee deliberated on these records to assess whether the solutions and action plans developed for previous issues were successfully implemented and resolved before action plans were made for subsequent implementations.

According to Peltó & Peltó (1978), validity is the degree to which scientific observations consistently measure or record what they purport to measure. While validity was originally understood to be nothing more than the proof that an instrument truly measures the things it is supposed to measure, validity has subsequently expanded to encompass a number of other ideas. For example, factors such as the degree of triangulation, the objectivity or indifference of the researcher, the participants, and the honesty, depth, richness, and breadth of the data obtained can all affect the validity of qualitative data (Winter 2000). Subjectivity, views, attitudes, and viewpoints of respondents all combine to generate bias in qualitative data. Accordingly, validity should be understood as a question of degree rather than as an absolute condition (Gronlund, 1981).

To enhance the validity of the study, the observation protocols and semi-structured interview questions were distributed to four faculty members from the Department of Curriculum and Instruction, apart from the validity committee members, to obtain their expert opinions. Additionally, the questionnaire underwent review by members of the validity committee. The insights and opinions provided by these experts informed the refinement of these data collection instruments, thereby bolstering their validity.

According to Yıldırım and Şimşek (2021), triangulation is the culmination of efforts made to use several data sources as well as various techniques for data collecting and analysis in order to boost the credibility of study findings. Triangulation is one of the most crucial methods for ensuring validity and reliability in qualitative research. Verifying information gleaned from observation through interview or verifying some findings from the interview through observation might be considered instances of triangulation. According to Denzin (1970), cited in Yıldırım and Şimşek (2021), the fundamental idea behind triangulation is to gather information from several sources using a variety of techniques in order to avoid biases or misconceptions in the result.

Four different forms of triangulations were differentiated by Denzin (1970), as referenced in Cresswell (2009). These triangulations include data, investigator, theory,

and methodology. Denzin (1989) distinguished between three primary forms of data triangulation: person, location, and time. Data triangulation, as defined by Denzin (1970), is the utilization of many data sources; this should be differentiated from the utilization of multiple data production techniques. Utilizing many observers or interviewers is known as investigator triangulation, and it is a technique used to identify and reduce the personal biases of the researcher. Theory triangulation is the process of examining data from several angles with several hypotheses in mind to increase the likelihood of discovering new information. The employment of many approaches, both within- and between-methods, to investigate a situation or phenomenon is known as methodological triangulation. Time triangulation allows observers to sample activities based on the day, week, month, or year, with an emphasis on the link to the continuing interactions.

In this study, time, researcher, and data triangulations were considered. To ensure triangulation and enhance the study's validity, data were gathered from various sources, encompassing records from validity committee meetings, reflection journals of both the researcher and students, observation field notes and protocols, semi-structured interviews, and questionnaires. Notably, data collection occurred at every stage of the study, spanning pre-implementation, during the implementation, and post-implementation, which lasted for three weeks. Furthermore, the data collected throughout the implementation underwent analysis by the validity committee members. This action also served as a form of triangulation, involving the validity committee members in identifying and resolving problems that emerged during the implementation.

Reliability in qualitative research is defined as the extent to which the data collected by researchers match the real events occurring in the natural setting under investigation in terms of both accuracy and coverage (Bogdan & Biklen, 1992). The takeaway for qualitatively oriented action researchers is straightforward: as you analyze the findings of your inquiry, ask yourself whether you believe that your data would be obtained consistently over time if the same methodologies were applied (Mills, 2014). In this study, reliability was ensured by employing consistent data collection methods across all phases of the research. Additionally, validity committee member checking and debriefing were utilized to validate the accuracy and authenticity of the findings.

An inter-coder reliability study was conducted with a validity committee member. The committee member was given 30% of the interview data without knowledge of the themes and subthemes developed by the researcher. The committee member

independently analyzed three students' interviews. The analysis results were compared with the theme sets, and the theme set was revised accordingly by the researcher and supervisors.

Several measures were implemented to enhance the research's credibility, transferability, trustworthiness, reliability, and validity:

- Sufficient time was dedicated to the research setting to comprehend the requirements and gather reliable data.
- The researcher documented experiences after each implementation in a reflective journal and on an observation protocol.
- All data collected from students during semi-structured interviews were promptly recorded and transcribed.
- The steps used for data collection and analysis were thoroughly documented, and the study method was comprehensively described.
- Throughout the analysis, deliberate efforts were made to objectively define and interpret the data.
- The interpretation of the data included direct quotations from the participants' viewpoints.
- The data results were presented comprehensively by establishing connections among them and linking them to the existing literature.
- The data collected during the research process underwent regular evaluations by the validity committee members to ensure the reliability of the implementation, and action plans were implemented in line with the committee members' opinions and suggestions.
- An endeavour was made to present the data collected during the research process consistently to complement each other.

2.9. Validity of this Action Research

Gall et al. (2003) noted that the growing number of action research studies has led to increased scrutiny of their validity. Within the interpretivist framework typical of action research, validity pertains to the credibility and trustworthiness of the findings. Herr and Anderson (2005) contend that traditional qualitative research standards may not always be applicable to action research. They proposed five specific validity criteria to evaluate the credibility and trustworthiness of action research studies. The following

sections describe these validity criteria and how they were addressed in the current action research, drawing on the work of Çardak (2012):

Outcome Validity: The validity of action research can be assessed by the extent to which the actions taken lead to resolving the initial problem that prompted the study. According to Herr and Anderson (2015), action researchers must be skilled in both research procedures and guiding participants towards effective action outcomes. This criterion essentially measures the success of the action research project in achieving its goals (Gall et al., 2003). In this study, the successful outcomes of the action plans were evidenced by weekly macroanalyses conducted by the researcher and validated by the validity committee during their meetings throughout the implementation process.

Process Validity: This assesses whether problems are framed and resolved in a way that supports ongoing learning for individuals or systems. Outcome validity is contingent on process validity; if the process is flawed, the outcome will reflect these flaws (Herr and Anderson, 2015). Hendricks (2006) emphasizes that process validity involves the accuracy of findings related to identified problems, their correct interpretation, and obtaining appropriate results. It also addresses what constitutes sufficient evidence to support assertions and the quality of relationships with participants (Herr and Anderson, 2015). Strategies recommended to ensure process validity include long-term data collection, data triangulation, accurate data recording, revealing biases, and peer questioning (Hendricks, 2006). In this study, the strategies proposed by Hendricks (2006) were implemented. The action research was conducted in a systematic weekly cycle. The researcher, who was also the students' science teacher, established strong interactions with the participants. All stages were closely monitored by the validity committee. Additionally, time, researcher, and data triangulations were employed, and the reliability of the analysis results was verified through comparisons with the validity committee's evaluations.

Democratic Validity: This refers to the extent to which research is conducted in collaboration with all stakeholders involved in the problem being investigated. While process validity relies on the inclusion of multiple voices for triangulation, democratic validity emphasizes the ethical and social justice aspects of including these voices (Herr and Anderson, 2015). In this study, informed consent was obtained from the students before the implementation. Their views, gathered through focus group interviews, questionnaires, and exit tickets, were considered as crucial evidence of their participation.

Additionally, the validity committee members actively participated in the data interpretation and the planning of action plans, ensuring a collaborative and inclusive research process.

Catalytic Validity: This refers to the extent to which the research process reorients, focuses, and energizes participants towards understanding and transforming their reality (Lather, 1986, cited in Herr and Anderson, 2015). In action research, this involves both participants and researchers being open to changing their perspectives and roles. The goal is for all involved to deepen their understanding of the social reality under study and to be motivated to take action to change or support it (Herr and Anderson, 2015). Gall et al. (2013) suggest that catalytic validity is enhanced by maintaining a research journal to document the researcher's evolving perspective and the changes in the research setting. In this study, the researcher maintained pre- and post-implementation reflection journals, while students expressed their thoughts through exit tickets, questionnaires, and focus group interviews, thereby ensuring catalytic validity. Additionally, the researcher conducted weekly macro-analyses of the data with the validity committee. This process involved identifying solutions to challenges encountered during implementation, developing action plans, integrating them into lesson plans, and reviewing them post-implementation. These activities helped participants deepen their understanding and take action regarding the studied issues.

Dialogic Validity: Dialogic validity in academic research is akin to the peer review process used to ensure the quality of research disseminated through academic journals (Herr and Anderson, 2015). Gall et al. (2013) describes dialogic validity as the value of engaging in dialogue with peers to form and review an action researcher's findings and interpretations. This can be achieved by conducting action research collaboratively or through reflective dialogue with other practitioner researchers or a "critical friend" who offers alternative explanations of the research data. In this study, the research process was closely monitored through continuous engagement with the validity committee. Four validity committee meetings were held throughout the implementation process, providing substantial evidence of dialogic validity. The researcher sought input from committee members at every stage, including the presentation of lesson plans, technological tools, data collection methods, and data analysis techniques. Necessary adjustments were made based on their suggestions and recommendations before implementation, ensuring a robust and reflective research process.

The researcher strived to attain all five types of validity specific to action research. By incorporating outcome, process, democratic, catalytic, and dialogic validity criteria, the study adopted a comprehensive and credible approach, aimed at producing reliable and actionable findings.

2.10. Precautions Taken Against Researcher Bias

Bias is inherent in human nature, and researchers may naturally exhibit biases during their studies. However, research standards dictate the importance of minimizing bias as much as possible in research. Consequently, researchers must implement measures to prevent and address biases. Additionally, it is crucial to transparently communicate the steps taken to address researcher bias in studies (Herr and Anderson, 2005). Notably, maintaining objectivity becomes more challenging in research where the researcher is a participant, as seen in action research. In such cases, it is emphasized that findings should undergo rigorous scrutiny to ensure they do not solely reflect personal biases (Mills, 2003; Herr and Anderson, 2005). Mills (2003) advocates for a systematic and disciplined research process as a key strategy for reducing researcher bias. On the other hand, Burns (1999) suggests examining reflective journals as a means of monitoring and addressing potential biases introduced by the researcher.

This study implemented several strategies, influenced by Çardak's (2012) research, to meticulously uncover and address researcher bias:

- The action research process adhered to a systematic and disciplined approach.
- Expert opinions were sought regarding the data collection instruments used during the implementation.
- Findings presented to the validity committee members in meetings underwent thorough scrutiny to ensure the objective collection and interpretation of data.
- The researcher maintained a regular and highly detailed reflection journals.

By incorporating triangulation studies, insights from validity committee members, and other validity-reliability studies, concerted efforts were made to mitigate the impact of researcher bias on the findings and subsequent actions.

2.11. Ethical Issues

Securing permission is paramount when conducting any study, especially in qualitative research such as action research involving human participants. Ethical

considerations, both before, during, and after the study, are crucial. In this study, the following ethical considerations were observed:

- Permission was sought and obtained from the Anadolu University Social and Human Scientific Research and Publication Ethics Board before commencing the study (see Appendix 1).
- Permission was secured from the Headmaster of the International Gokkusagi Schools in Ankara before the implementation phase. Then from the Ministry of National Education (see Appendix 2)
- Prior to the study, verbal consents were obtained from the students, and subsequent permissions were acquired through the Student Consent Form, covering participation in the research, interviews, questionnaires, and overall involvement in the study. In addition, parental consent letters with a detailed explanation of the research were delivered and signed voluntarily. (see Appendix 14).
- Students were explicitly assured of voluntary participation, the right to withdraw at any point, as well as guarantees of anonymity and confidentiality

3. FINDINGS

This chapter encompasses the findings and interpretations derived within the context of this action research. Following the analysis of the collected data, the results were presented and interpreted in alignment with the study's aim, ultimately addressing the research questions. Both qualitative and quantitative data were gathered within the framework of the study. The findings from the qualitative data were organized into themes and subthemes and subsequently interpreted using inductive thematic analysis. Conversely, the findings from the quantitative data were organized into tables and graphs and analyzed descriptively. While presenting the findings, the results were organized chronologically according to the weeks in which the implementation occurred, providing a clear picture of how events unfolded over time. Therefore, the findings for each week are presented to describe the implementation process in detail. Following this, thematic analysis and descriptive statistics are presented in accordance with the research questions.

3.1. Findings from the First Week of Implementation

Data from the first implementation, gathered from the researcher, students, and validity committee members, is presented in this section. The findings that emerged from the data are also presented chronologically, covering the beginning, during, and end phases of the first week's implementation.

Table 5. *Summary of the lesson plan, technological tools, and the data collection instrument utilized throughout the first implementation*

Course Title	Science
Class	7 th Grade
Unit	Unit 3: Forces and Energy
Topic	3.1: Force and Motion
Time	80 Minutes
Date	20 th November, 2023
Course Book	Cambridge Lower Secondary Science Learner's Book 8
Learning Objectives	By the end of the lesson the students will be able to: • Understand what is meant by balanced and unbalanced forces. • Describe the effects of balanced forces on motion. • Describe the effects of unbalanced forces on motion.
Technology Integration Tools	• Video • Animation • Simulation • Wordwall • Kahoot
Data Collection Instruments Utilized Throughout the Implementation	1. Researcher's pre-implementation reflection journal 2. Observation field note 3. Observation protocol 4. Students' reflection journal 5. Questionnaire 6. Semi-structured focus group interview 7. Researcher's post implementation reflection journal 8. Validity committee meeting records

In Table 5, a summary of the lesson plan, technological tools, and data collection instruments utilized throughout the first implementation is presented. The lesson duration was 80 minutes, equivalent to two class periods. Furthermore, the lesson focused on the topic of forces and motion, specifically under unit three of forces and energy from the Cambridge Lower Secondary Science Learner's Book 8. This implementation took place on November 20, 2023, with 7th-grade students. The learning objectives for this implementation aim to enable students to comprehend the concepts of balanced and unbalanced forces, describe the effects of balanced forces on motion, and articulate the effects of unbalanced forces on motion. The technological tools integrated during the implementation encompassed simulation, animation, video, Wordwall, and Kahoot. Lastly, the data collected throughout this implementation included the researcher's pre-implementation reflection journal, observation field notes, observation protocol, students'

reflection journals, questionnaire, semi-structured interview, researcher's post-implementation reflection journal, and validity committee meeting records.

3.1.1. Findings from the researcher's pre-implementation reflection journal

The reflection journal written by the researcher before the implementation contained information about how the implementation was anticipated. The topics covered in the researcher's reflection journal were utilized as themes, and these themes were analyzed descriptively. Seven themes emerged from the researcher's pre-implementation reflection journal, and they are presented below:

1. Purpose of Implementation
2. Technological Tools
3. Reasons for Tool Selection
4. Sources of Technological Tools
5. Integration Process and Phases
6. Soliciting Feedback from Students
7. Anticipated Problems

3.1.1.1. Purpose of implementation

The first theme that emerged in the researcher's pre-implementation was centered around the purpose for which the implementation was conducted. A distinct connection was observed between the overarching purpose of the study and the specific purpose of the implementation. While these purposes were interconnected, they were not identical. The collective aim of the implementation was ultimately to contribute to the achievement of the study's purpose. In this context, the researcher articulated the following insights concerning the purpose of the action research:

"This marks the implementation phase of my action research, which is focused on discovering effective methods to integrate technology into the teaching and learning process of the science course." (Ankara, 19th November, 2023, Line Number: 2-4).

After elucidating the primary objective of the action research, the researcher proceeded to articulate the specific purpose for which the implementation was undertaken. The researcher expressed this as follows:

"My aim is to improve my instructional approach, identify technological tools that can enhance students' understanding of key science concepts, and address any challenges that

may arise during the integration of technological tools into the science lesson.” (Ankara, 19th November, 2023, Line Number: 4-7).

It can be inferred from the researcher's statement above that he was expressing his commitment to refining his instructional approach as a science teacher. This aligns with one of the purposes of action research, also known as teacher research, wherein the teacher takes action to improve their instructional approach or address issues in the instructional environment. Additionally, the researcher aimed to enhance students' understanding of certain scientific concepts through the integration of technological tools into the instructional process. Like any other instructional method, technology integration is susceptible to challenges that may impede the smooth flow of instruction. However, the researcher has also made it imperative to address and resolve any problems that will arise during the implementation due to the integrated technological tools.

3.1.1.2. Technological tools

During the implementation, the researcher identified several technological tools intended to be integrated into the science lesson to engage students and facilitate an enhanced understanding of scientific concepts. The technological tools the researcher planned to integrate into the science lesson comprised video, animation, simulation, Cambridge Lower Secondary Science Stage 8 software, and other online games. The researcher elaborated on this by stating the following:

“I plan to enhance the science lesson by integrating various technological tools, including video, animation, simulation, Cambridge Lower Secondary Science Stage 8 software, and online games.” (Ankara, 19th November, 2023, Line Number: 8-10).

These technological tools have the capacity to establish a dynamic and engaging learning environment that considers the diverse learning needs of students. The classroom, functioning as a discourse community with students possessing varied learning requirements, is transformed into an interactive learning space through the integration of these technological tools. This facilitates a learning environment where education is coupled with enjoyment, thereby enhancing the understanding of scientific concepts.

3.1.1.3. Reasons for technological tool selection

The researcher elaborated on both the purpose of the action research and the purpose of the implementation. Furthermore, he delved into the rationale behind the

selection of the technological tools intended for implementation in the science lesson. In this regard, he stated that:

“The chosen topic for this implementation is forces and motion, a subject laden with abstract concepts such as gravity, contact force, and friction. To facilitate a better understanding of these complex ideas, I aim to present the technological tools in a clear and easily digestible manner. Utilizing videos and animations, I will cover balanced and unbalanced forces as well as Newton’s Third Law of Motion. These visual aids will serve as audio-visual learning resources, making it easier for students to grasp the concepts involved. The animation will also guide students through a step-by-step simulation activity, providing practical insights into proving Newton’s Third Law of Motion.” (Ankara, 19th November, 2023, Line Number: 12-19).

In the aforementioned entry from the researcher's pre-implementation reflection journal, he mentioned that the chosen science topic for implementation involves abstract concepts such as gravity, contact force, and friction. Consequently, the primary rationale for selecting and subsequently integrating these technological tools into the lesson is to facilitate the students' comprehension of these abstract concepts. The videos and animations, being audio-visual learning resources, are expected to aid students in grasping the discussed concepts. Additionally, the researcher highlighted that the integration of animation would provide students with a step-by-step demonstration, preparing them for a simulation task later in the lesson.

The researcher also specified that a simulation is one of the technological tools to be integrated into the science lesson. The purpose of integrating the simulation is to enable students to engage in real-world scenarios by immersing themselves in a computer simulation. In this context, the researcher stated that:

“I have selected simulations, which will allow the students to perform activities based on the animations they will watch.” (Ankara, 19th November, 2023, Line Number: 19-20).

At the end of the implementation, the researcher planned to utilize Kahoot and Wordwall for assessing the students' understanding post-lesson. The researcher recorded the following in his pre-implementation reflection journal regarding this aspect:

“To assess their understanding of the lesson, I will integrate engaging games such as Wordwall and Kahoot.” (Ankara, 19th November, 2023, Line Number: 21-22).

3.1.1.4. Sources of technological tools

The technological tools the researcher intended to integrate into the science lesson were sourced from various sources. The researcher elaborated on these sources and

underscored the accessibility and openness of the technological tools, with the majority being freely and readily available on the internet. The researcher expounded on this as follows:

“I have selected simulations from OLABS and PhET.” (Ankara, 19th November, 2023, Line Number: 19).

One of the simulations, together with the video and animation, were sourced from Amrita OLabs, which is an initiative by Amrita E-Learning Research Lab under Amrita University, India. Amrita OLabs provides a virtual laboratory environment for students to perform various science experiments online. It also provides resources like theory, procedure, animation, simulator, video, viva voce, and resources about a topic under study. And above all, it is free and readily available on the internet ([http-1](#)). PhET, on the other hand, is an interactive simulation developed by the University of Colorado Boulder. PhET provides free interactive math and science simulations, allowing students to explore and understand various scientific concepts through virtual experiments. These simulations cover a wide range of topics, including physics, chemistry, biology, earth science, and mathematics. PhET simulations are designed to be user-friendly, visually engaging, and aligned with educational standards ([http-2](#)).

With the technological tools used for assessing the students at the end of the lesson, the researcher indicated that Kahoot and Wordwall would be used. The researcher recorded the following regarding their source, accessibility, and openness:

“To assess their understanding of the lesson, I will integrate engaging games such as Wordwall and Kahoot. While the former is open-access, it is worth noting that I have subscribed to Kahoot's free account and personally curated the assessment questions. Additionally, all these technological tools were evaluated during our first validity committee meeting, where members deemed them appropriate for the students' level. Furthermore, it is important to highlight that, except for Kahoot, all the other technological tools are freely available on the internet, aligning with the accessibility and openness of the educational resources chosen for this lesson.” (Ankara, 19th November, 2023, Line Number: 21-27).

After procuring the technological tools from diverse sources, the researcher also mentioned that these tools underwent a thorough review, vetting, and approval process by the validity committee (Validity Committee Meeting No. 1) for use in the lesson.

3.1.1.5. Integration process and phases

The researcher outlined the strategies for the seamless integration of technological tools into the lesson, emphasizing a smooth transition between different phases of the lesson. Regarding the integration process, the researcher elaborated on how the classroom would be arranged and organized to receive the technological tools, ensuring maximum benefits for the students. The researcher documented the following:

“Additionally, prior to implementing the lesson, I will have all the technological tools opened and minimized on the smartboard. I will repeat this on the laptops assigned to the students for the lesson. Following this, I will organize the seating arrangement by transitioning them from rows to two groups, each comprising four desks, given that there are eight students in the class.” (Ankara, 19th November, 2023, Line Number: 28-31).

After establishing the learning environment for the implementation, the researcher documented the chronological order in which the lesson would unfold and the technological tools to be integrated during each phase. The researcher recorded this process as follows:

“Following the technological tools setup, I will commence the lesson with the assistance of the Cambridge Lower Secondary Science Stage 8 software. I will use this platform to introduce the lesson, outline the objectives, and highlight the technological tools that will be integrated into the lesson. Subsequently, I will engage the students by displaying a video, serving both as an introduction to the lesson and a catalyst for a discussion to address the introductory questions.” (Ankara, 19th November, 2023, Line Number: 32-36).

The researcher also outlined the activities to be conducted during the implementation process and specified the technological tools that would be integrated at each phase. The researcher also shed light on his and the students' roles during this phase, emphasizing these aspects by capturing the following in his pre-implementation reflection journal:

“As the lesson progresses, I will strategically incorporate video and animation when needed, enhancing the explanation of abstract concepts. When it is time for the simulation task, the animation will guide the students by displaying instructions before they collaboratively undertake the task. During this phase, some students will be tasked with reading the instructions, while others will execute them. I will be present to offer support and guidance, by providing scaffolding where necessary to ensure a comprehensive understanding of the technological tools and the tasks.” (Ankara, 19th November, 2023, Line Number: 37-43).

At the end of the implementation, the researcher stated that the lesson would be summarized and various technological tools would be employed to assess the students' understanding. Information regarding the types of assessment tools that would be utilized

and how the assessment itself would be conducted was captured as follows by the researcher:

“Following the simulation task, I will wrap up the lesson by summarizing the lesson and addressing any lingering questions or concerns the students may have. Subsequently, we will transition to the assessment phase of the lesson, utilizing Wordwall and Kahoot. For the Wordwall assessment, students will collaboratively respond to questions as a group. They will take turns answering questions, with Group 1 tackling the first question and Group 2 handling the second, in that order. Moving to Kahoot, the assessment will continue collaboratively, but with a slight modification. Instead of using their phones, the students will use their laptops to collaboratively answer the questions. This collaborative approach aims to encourage teamwork and shared understanding as they navigate the assessment challenges together.” (Ankara, 19th November, 2023, Line Number: 44-52).

3.1.1.6. Soliciting feedback from students

At the end of the implementation, diverse methods, including questionnaires, students' reflection journals in the form of stickers, and focus group interviews, would be employed to gather comprehensive feedback from students. The researcher captured information on how this feedback would be solicited from the students as follows:

“In the post-implementation phase, I will initiate data collection from the students through various methods. Initially, I will distribute a three-question questionnaire aimed at eliciting their ratings and opinions on the challenges faced during the lesson, the impact of technological tools on their understanding, and their overall enjoyment of the science lesson. Following this, each student will be provided with a sticker to articulate their personal experiences with the integration of technological tools into the lesson. To delve deeper into their perspectives, a focus group interview will be conducted, comprising four students from each group. The interview will centre around their experiences with the technological tools, any encountered challenges or problems, how these challenges or problems were resolved, and the extent to which the tools enhanced their understanding and performance in the lesson.” (Ankara, 19th November, 2023, Line Number: 53-62).

The feedback from the students constitutes a valuable and rich dataset to be utilized in the analysis of the implementation. Additionally, the researcher gathered another set of information, including self-solicited observations during the lesson. These observations will be documented in two forms, as outlined by the researcher: observation field notes and observation protocols. Below is the information recorded by the researcher in that regard:

“Simultaneously, I will diligently document my observations in a detailed field note. This information will be used to complete the observation protocol and contribute to the post-

implementation reflection journal. The analysis of data from these diverse sources will provide a comprehensive understanding of the impact of technology integration on the students' learning experiences, allowing for valuable insights and future improvements.” (Ankara, 19th November, 2023, Line Number: 63-67).

3.1.1.7. Anticipated problems

At the end of the pre-implementation reflection journal, the researcher outlined challenges that could potentially impede the seamless integration of the technological tools into the lesson, potentially disrupting the entire learning process. Reflecting on this issue, the researcher underscored the importance of preparing for unforeseen circumstances and emphasized the necessity of developing contingency plans during implementation to address any unexpected challenges. The researcher captured this as follows:

“Dear diary, to be honest, I find myself in a state of nervous anticipation about what lies ahead tomorrow. The plans I have meticulously crafted for implementation are teetering on the edge of uncertainty. My mind is clouded with worries—what if time slips away before I can seamlessly integrate all the technological tools into the lesson? What if the students become overwhelmed by the array of tools I have prepared? And then there's the looming fear of the unpredictable, like the Wi-Fi acting up or an unexpected blackout disrupting our plans. These questions relentlessly echo in my mind, creating a sense of unease. At this juncture, I can only hope and pray that everything unfolds according to plan. The anxiety is palpable, but I choose to embrace optimism. See you after implementation.” (Ankara, 19th November, 2023, Line Number: 68-76).

According to this quotation, the researcher foresees potential problems such as students becoming overwhelmed by the technological tools integrated into the lesson, which could disrupt the entire classroom order. Additionally, the researcher expressed concerns about potential Wi-Fi or electricity outages, which could also disrupt the lesson. These concerns highlight possible issues that could arise and impact the smooth execution of the lesson.

3.1.2. Findings from the researcher's observation field note

The observation field note served as the written record encompassing the observations, insights, and reflections made by the researcher during the science lesson integrated with technological tools. It documented detailed behaviors and contextual information about the students throughout the lesson. The data from the observation field

note underwent analysis using thematic analysis, resulting in the emergence of seven themes and their respective sub-themes. Various patterns, recurring topics, and significant concepts derived from the observation field notes served as references in forming these themes and sub-themes. The themes and sub-themes are presented in Table 6.

Table 6. *Themes and sub-themes emerged from the researcher's observation field note during the first implementation*

Themes	Sub-themes
1. Integration of Technological Tools	Rationale for Integration Seating Arrangement Adjustment Interactive Learning with Technology
2. Lesson Introduction and Objectives	Introduction of Lesson Prior Knowledge Assessment
3. Simulation and Hands-On Activities	Simulation Tasks Hands-On Activities
4. Lesson closure	
5. Assessment with Technological Tools	Wordwall and Kahoot Integration Scoring and Feedback
6. Problems Encountered and Their Solutions	Time Constraints Techno-Centric Distractions Excessive Technology Integration Adaptations During the Lessons
7. Reflection of the Students	

3.1.2.1. Integration of technological tools

Under this theme, the researcher detailed three events that transpired in the classroom before the lesson. These included the rationale for integrating technological tools into the science lesson, the adjustment of seating arrangements to accommodate the technological tools to be integrated, and interactive learning with technology. The researcher recorded the following in the observation field note as his intention for entering the classroom:

“Upon entering the classroom, I brought along two laptops and the Cambridge Lower Secondary Science Stage 8 textbook, with the intention of integrating technological tools into my science lesson.” (20th November, 2023, Observation Field Note, Line Number: 1-3).

However, in order to integrate the technological tools into the science lesson, there were some arrangements that had to be made to accommodate the technological tools into the lesson and also ensure the students would ultimately benefit from the technological tools. On this note, the researcher recorded how he adjusted the classroom seating arrangement as follows:

“My initial step involved rearranging the students' seating arrangement from rows to two groups. In total, there were eight students in the classroom, with one student absent on that

day. The first group was composed of three female students and one male student, while the second group included two male students and one female student. By 10:22am, the students were comfortably seated, each group equipped with a laptop in front of them.” (20th November, 2023, Observation Field Note, Line Number: 3-7).

After arranging the seating, the researcher proceeded to elaborate on the rationale behind adjusting the seating from rows to two groups. The researcher stated the following:

“This setup aimed to enhance the science lesson through interactive and collaborative learning facilitated by the use of technology.” (20th November, 2023, Observation Field Note, Line Number: 7-9).

3.1.2.2. Lesson introduction and objectives

This theme highlighted the events that ensued after the seating arrangement. These events comprised the introduction of lessons, encompassing the presentation of the topic and the outlining of lesson objectives. Furthermore, the researcher detailed the technological tools slated for integration into the lesson and elucidated the rationale behind their incorporation. The researcher recorded this in that regard:

“Following the seating arrangement adjustments, I proceeded to open the Cambridge Lower Secondary Science Stage 8 software on the smartboard. With the software displayed, I took a moment to introduce the topic and outline the objectives of our lesson. I made it clear to the students that our approach today would involve the integration of technological tools into the science lesson. The primary goal was to explore the effective integration of technology, emphasizing how it could elevate the students understanding and enjoyment of the lesson. I then provided an overview of the specific technological tools we would be utilizing, which included a video, an animation, two simulations from OLABS and PhET, as well as Wordwall and Kahoot. This variety of technological tools aimed to add a dynamic and interactive dimension to our science lesson, fostering a more engaging and enriching learning experience for the students.” (20th November, 2023, Observation Field Note, Line Number: 10-20).

After introducing the lesson, the researcher mentioned that he proceeded to assess the students' relevant prior knowledge about the topic of discussion. This step was crucial for setting the stage for the lesson before integrating various technological tools into the lesson content. The researcher recorded how this was carried out as follows:

“After introducing the lesson, we then had a quick question and answer session to assess the relevant prior knowledge of the students.” (20th November, 2023, Observation Field Note, Line Number: 21-22).

3.1.2.3. Simulation and hands-on activities

In the middle of the lesson, the researcher strategically selected and integrated a video, an animation, and simulations from OLABS and PhET to engage students in a practical exploration of Newton's Third Law of Motion. During this phase, the video was initially integrated into the lesson, and the researcher recorded how he went about it as follows:

“Subsequently, we proceeded to watch a short video from OLABS, elucidating the topic of forces and motion, with a particular emphasis on Newton's Third Law of Motion. After watching the video, we returned to the Cambridge Lower Secondary Science Stage 8 software displayed on the smartboard and continued with the lesson.” (20th November, 2023, Observation Field Note, Line Number: 22-25).

After the students finished watching the video, it was time for them to engage in a hands-on activity using a simulation of Newton's Third Law of Motion. However, before the students could carry out the simulation task, there was a need for them to be guided on how to go about it. This rationale influenced the integration of the animation. The researcher elaborated on this as follows:

“Next, we delved into the section of the lesson that involved a hands-on activity for students to demonstrate Newton's Third Law of Motion. I clarified to the students that this particular activity would be conducted using a simulation. As this part of the lesson unfolded, we found ourselves with approximately five minutes remaining before the scheduled break. Utilizing this time effectively, I introduced an animation from OLABS, outlining the materials essential for the upcoming activity and providing a step-by-step guide on how to execute it. By 10:50 am, the designated break time had arrived, prompting the students to leave the classroom.” (20th November, 2023, Observation Field Note, Line Number: 26-32).

After the students had completed the animation and were more familiar with how to carry out the simulation task, the researcher introduced the two simulations from OLABS and PhET for the students to perform the tasks. The researcher recorded how they carried out the task and their demeanour as follows:

“I proceeded to maximize the simulation windows on the students' laptops, allowing them to collaboratively engage in the simulation task. One student assumed the role of reading the task instructions, while the other group member(s) actively executed the task. This specific simulation, sourced from OLAB, centered around demonstrating Newton's Third Law of Motion. As the students carried out the activity, I could see they were really into it. They were talking and smiling a lot, showing they were genuinely enjoying it. After we completed the first simulation, we moved on to the second simulation from PhET. This simulation task centered around balanced and unbalanced forces, digging into the effects of forces on an

object. The students kept up their enthusiasm, exploring different scenarios and having a good time with it.” (20th November, 2023, Observation Field Note, Line Number: 38-46).

3.1.2.4. Lesson closure

After completing the simulation tasks, the researcher proceeded with the lesson on calculating the net force acting on an object, marking the conclusion of the lesson. Subsequently, a lesson closure was conducted, wherein the lesson was summarized and all the students' questions were addressed. The researcher captured this as follows:

“Following the simulation tasks, we returned to the lesson displayed on the smartboard. We dove into the topic of calculating the net force acting on an object. I broke down the concepts and walked the students through numerous examples on the whiteboard using a marker. After this hands-on session, we wrapped up the lesson with a brief closure. During this time, the students mainly asked questions, focusing particularly on the calculations of the net force. I addressed all their queries. By this point in the lesson, it was around 11:20 am, and we had roughly 20 minutes left to finish with the remaining assessment activities.” (20th November, 2023, Observation Field Note, Line Number: 47-53).

The lesson closure signalled the conclusion of the lesson, seamlessly transitioning to the end of the implementation. This phase marked the initiation of the assessment, where the researcher evaluated the students' understanding and the effectiveness of the integrated technological tools.

2.1.2.5. Assessment with technological tools

The assessment phase marked the end of the lesson, with the researcher integrating Wordwall and Kahoot to assess the students' understanding. At this phase, the students actively participated in the assessment activities, and their performance demonstrated a solid grasp of the lesson content. The researcher recorded how the assessments were conducted as follows:

“The technological tools used lastly, thus at the assessment stage were, Wordwall and Kahoot. Initially, the task was projected onto the smartboard, and the students collaboratively responded to the questions as a group. The Wordwall game featured ten questions, focusing specifically on the calculation of the net force acting on objects. Subsequently, we engaged in a Kahoot session, comprising ten questions covering the entire lesson. The students participated in the Kahoot on their laptops, collaborating within their groups. Notably, the students really enjoyed these online games, showcasing enthusiastic collaboration as they worked together to formulate answers. Their responses provided me

with assurance that the lesson had been well understood.” (20th November, 2023, Observation Field Note, Line Number: 54-61).

Under this theme, the second sub-theme, "scoring and feedback," illuminated how the students' performance in the assessment activities in Wordwall and Kahoot reflected their comprehension of the lesson content. The researcher documented this encounter as follows:

“In the Wordwall game, both groups achieved a perfect score of 5/5. In the Kahoot session, both groups scored 9/10, with the first group securing the top spot on the scoreboard. Their quicker responses earned them extra points. Although the students expressed a desire to continue playing Kahoot, time constraints prevented further games. This activity marked the end of the lesson.” (20th November, 2023, Observation Field Note, Line Number: 61-66).

2.1.2.6. Problems encountered and their solutions

Under this theme, the researcher elaborated on the problems that emerged during the implementation and how the problems were resolved. As the researcher had anticipated in the pre-implementation reflection journal, problems were expected in the lesson integrated with technological tools. Indeed, during the implementation, the researcher observed three problems: lack of time, technocentric distraction, and excessive integration of technological tools. The researcher succinctly captured these problems as follows:

“Throughout the implementation, three significant challenges emerged: lack of time, technocentric distractions, and an excessive integration of technological tools.” (20th November, 2023, Observation Field Note, Line Number: 79-20).

The first problem that the researcher observed was time constraints, primarily stemming from challenges in managing time due to the integration of technological tools into the lesson. The researcher expounded on this in the observation field note, shedding light on the intricate dynamics of time management influenced by the integration of these tools. The researcher also elaborated on how he resolved the problem while in the instructional setting. The researcher recorded this incident as follows:

“Firstly, the issue of time posed a notable challenge. It took nearly twenty minutes to arrange the seating, set up the students' laptops, and open and log into the various technological tools, including the Cambridge Lower Secondary Science Stage 8 software. To address this concern, I adapted by utilizing the break time to open and log into the technological tools, recognizing that doing so during the regular lesson period would be time-consuming. Time constraints resulting from the integration of numerous tools meant that the original lesson plan could not be fully executed. Additionally, due to a lack of time, the students were unable

to complete their reflection journals in the classroom. Completing this reflection task within the classroom setting would have allowed them to share their experiences while the lesson was still fresh in their minds.” (20th November, 2023, Observation Field Note, Line Number: 21-22). (20th November, 2023, Observation Field Note, Line Number: 80-89).

The researcher also addressed the second issue that emerged, namely, techno-centric distractions, where students became overly engrossed in the technological tools integrated into the lesson, particularly the simulations. This behavior led to various forms of distraction, diverting their attention away from the lesson and toward the technological tools. The researcher elaborated on this challenge and how he mitigated it in his observation field note as follows:

“The issue of techno-centric distractions surfaced as students became overly engrossed in the technological tools, particularly the simulations, diverting their attention away from the teacher and the core lesson content. Even after the designated task, some students continued to engage in unrelated activities on their laptops, detracting from the ongoing lesson. To address this challenge, I implemented a solution by minimizing all the open windows and putting the laptops to sleep during periods when the students were supposed to focus solely on the teacher and participate in the lesson. This approach effectively redirected their attention back to the lesson, fostering increased participation and attentiveness. Laptops were only opened and utilized during specific sections of the lesson, such as when carrying out simulation tasks or playing Kahoot. This strategy aimed to strike a balance between leveraging technology for enhanced learning experiences and maintaining a focused and engaged classroom environment.” (20th November, 2023, Observation Field Note, Line Number: 90-100).

In his observation field note, the researcher also detailed the final problem: excessive technology integration that he encountered during the lesson. The researcher identified the integration of numerous technological tools in the lesson as an issue disrupting the lesson's natural flow. Expressing concern that the number of integrated tools within the specified timeframe was excessive, the researcher acknowledged the need for adjustments in subsequent implementations. Nonetheless, this is what the researcher recorded in his observation field note about the issue:

“The issue of excessive technology integration emerged as a challenge during the lesson, marked by the integration of multiple technological tools within a short timeframe. The lesson integrated a video, an animation, and simulations from OLABS and PhET, as well as Wordwall and Kahoot. The transition from one technological tool to another consumed valuable lesson time. Unfortunately, this problem was recognized post-lesson, preventing immediate remediation in the classroom setting. However, a plan has been devised to address this concern in subsequent lessons. The approach will involve a more deliberate selection of

technological tools, ensuring their clear alignment with instructional objectives. The goal is to integrate the most relevant tools, incorporating at least one video, animation, simulation, and an online game. Additionally, for assessment purposes, the plan is to consolidate the games into a single platform, preferably Kahoot, given its popularity among the students. This strategic move aims to strike a balance, ensuring the effective use of technological tools without overwhelming the students and allowing for better time management to cover other essential aspects of the curriculum or lesson.” (20th November, 2023, Observation Field Note, Line Number: 101-114).

Additionally, during the lesson, the researcher implemented strategic adaptations. Thus, during break time, the researcher executed plans by arranging the technological tools to be used after the break systematically, minimized distractions by regulating laptop usage, and established future strategies for more efficient integration of technological tools into the lesson to enhance time management. The researcher documented these actions in the observation field note as follows:

“During the ten-minute break, I took the opportunity to set up the simulations, Wordwall, and Kahoot on both the students' laptops and on the smartboard. To ensure their full engagement, I minimized all windows on the students' laptops, directing their attention toward the activities displayed on the smartboard. By 11:00 am, as the students returned from the break, they took their seats within their respective groups, fully prepared to embark on the simulation task.” (20th November, 2023, Observation Field Note, Line Number: 33-37).

2.1.2.7. Reflection of the students

After the lesson, the researcher conducted a comprehensive assessment, distinct from the student assessments with technological tools like Wordwall and Kahoot. The researcher facilitated a post-lesson reflection using a questionnaire and a reflection journal in the form of an exit ticket, where the students penned their reflections about the whole implementation. The researcher documented this phase of the implementation as follows:

“After the completion of the assessment activities, I informed the students that they would be required to fill out a brief questionnaire reflecting on their experience with the technology-integrated science lesson. At this point, it was around 11:31 a.m., leaving us with approximately nine minutes before the students would head out for their lunch break. The questionnaire delved into their encounters with any challenges during the technology-integrated lesson, how the technological tools contributed to their understanding, and their overall enjoyment of the lesson due to the integrated technology. The questionnaire included a rating scale from 1 to 10 for them to express their experiences. Once I explained the questionnaire and its components, I rearranged their seating from groups into rows. The

students then individually completed the questionnaire. Additionally, I asked them to write an exit ticket—a brief reflection on the lesson. Although the lesson had officially ended, I encouraged them to jot down their thoughts immediately upon returning from lunch. True to their commitment, the students did so promptly.” (20th November, 2023, Observation Field Note, Line Number: 67-78).

3.1.3. Findings from the researcher’s observation protocol

During the lesson, the researcher, guided by an observation protocol, made observations regarding the interactions among the students and the technological tools integrated into the lesson. The observation protocol comprised a structured framework that the researcher utilized to systematically record and document the students' behavior during the session. Furthermore, the observation protocol included both descriptive and reflective notes. The descriptive notes provided detailed, chronological accounts of what the observer saw and heard, along with occurrences in the physical setting. On the other hand, the reflective notes consisted of concurrent remarks about the observer's thoughts, personal reactions, and experiences. As thematic analysis was employed to analyze the findings from the observation protocol, themes and sub-themes were identified. The descriptive notes from the observation protocol served as a point of reference for the development of these themes and sub-themes. Table 7 presents the themes and sub-themes identified from the observation protocol.

Table 7. *Themes and sub-themes emerged from the researcher’s observation protocol during the first week’s implementation*

Themes	Sub-themes
1. Integration of Technological Tools	Technological Tools Utilized Technological Tools Integration Phases
2. Utilization of Technological Tools in Lesson Activities	Initial Activities Mid-Lesson Activities Concluding Activities
3. Students' Interaction and Participation in the Lesson	Beginning-of-Lesson Response Mid-Lesson Interaction End-of-Lesson Engagement Attentive Observation Collaborative Group Work Diverted Attention
4. Problems and Challenges Faced by Students Using Technological Tools	No Major Student Challenges
5. Resolution of Problems and Challenges Encountered	Mouse Functionality Adjustment
6. Impact of Technological Tools on the Classroom Environment	Seating Arrangement Change Enhanced Interaction and Support

3.1.3.1. Integration of technological tools

The technological tools integrated into the lesson were detailed by the researcher in the observation protocol as follows:

“Various technological tools were integrated in the lesson, including a video, an animation, two simulations, Wordwall, and Kahoot.” (Observation Number 1, Date: 20th November, 2023).

The second sub-theme that emerged from this theme pertains to the stages at which the technological tools were integrated into the lesson. The researcher utilized and incorporated the technological tools in distinct phases, commencing from the beginning, progressing through the middle, and concluding at the end of the lesson. The researcher provided further details on this in the observation protocol, as follows:

“The video was presented at the outset, while in the middle of the lesson, both the animation and simulations were seamlessly integrated. Finally, during the assessment stage at the end of the lesson, Wordwall and Kahoot were integrated.” (Observation Number 1, Date: 20th November, 2023).

3.1.3.2. Utilization of technological tools in lesson activities

Under this theme, the researcher provided insights into the learning activities facilitated by the integrated technological tools. Three sub-themes emerged, delineating the initial activities, mid-lesson activities, and concluding activities.

During the initial activities, the researcher integrated a video, strategically employed to deliver a succinct and vivid introduction to the topic. This served a dual purpose of providing a clear overview and establishing the foundation for the lesson. The researcher expounded on this in the observation protocol as follows:

“At the outset of the lesson, I utilized a video displayed on the smartboard to deliver a concise and vivid explanation of the topic at hand. This visual aid served as an effective introduction, setting the stage for the lesson.” (Observation Number 1, Date: 20th November, 2023).

In the middle of the lesson, the researcher seamlessly incorporated an animation and a simulation. The animation was utilized to offer the students a step-by-step demonstration of the simulation activity they would later undertake in the lesson regarding Newton's Third Law of Motion. The researcher provided further details on this event in the observation protocol, as follows:

“Midway through the lesson, an animation sourced from OLABS took centre stage. It provided a step-by-step guide and visually demonstrated the procedure for conducting an experiment to illustrate Newton's Third Law of Motion. The lesson progressed with the

students actively engaging in a simulation from OLABS. This simulation allowed them to practically carry out an experiment to prove Newton's Third Law of Motion, fostering a hands-on learning experience. Additionally, another simulation from PhET was integrated, offering the students an opportunity to explore the dynamics of balanced and unbalanced forces acting on an object.” (Observation Number 1, Date: 20th November, 2023).

Finally, at the end of the lesson, the technological tools utilized by the researcher included Wordwall and Kahoot. The students worked collaboratively with each other to complete the assessment tasks. The researcher provided further details on this integration in the observation protocol as follows:

“For the assessment stage, Wordwall and Kahoot were employed. The students, working collaboratively in groups, played these interactive games on their laptops. This marked the conclusion of the lesson, providing a dynamic and engaging platform for assessing their understanding of the lesson.” (Observation Number 1, Date: 20th November, 2023).

3.1.3.3. Students' interaction and participation in the lesson

Various technological tools were seamlessly integrated into the lesson. Consequently, students instructed with these tools exhibited diverse interactions and reactions. These interactions and reactions were not uniform throughout the lesson. Some variations were observed throughout the lesson, stemming from the beginning, middle, and end of the session. These varied interactions at different stages led to the emergence of sub-themes elucidating the beginning-of-lesson response to the technological tools, mid-lesson interactions, and end-of-lesson engagement of the students with the technological tools.

At the beginning of the lesson, when the video was presented to the students, they engaged in passive observation, focusing solely on the content presented in the video. The researcher documented this interaction as follows:

“Overall, the students were highly engaged in the tasks they completed on their laptops. They solely focused on observing the video and animation without engaging in any activities on either their laptops or the smartboard.” (Observation Number 1, Date: 20th November, 2023).

In the middle of the lesson, the students displayed generally positive responses towards the integrated technological tools. Observations revealed that the students were nodding in agreement during the presentation of the animation. This indicated a high level of focus and active engagement with the instructional content. Furthermore, the students participated in a collaborative simulation task, further enhancing their engagement with the integrated technological tools. The researcher detailed this observation as follows:

“Following the display of the video at the beginning and the animation in the middle of the lesson, the students were seen nodding their heads in agreement, signalling a clear understanding of the content. Notably, their smiling faces further indicated understanding and enthusiasm for the lesson. Moreover, based on my observations, the students exhibited a positive and collaborative attitude as they worked on simulation tasks, Wordwall, and Kahoot on their laptops during the middle and at the end of the lesson.” (Observation Number 1, Date: 20th November, 2023).

At the end of the lesson, the students were actively involved in the assessment activities designed to assess their understanding of the lesson. During this phase, Wordwall and Kahoot were utilized. Notably, the students demonstrated active participation and expressed enjoyment during this part of the lesson. The researcher provided further details on this event as follows:

“Their enjoyment was particularly evident during the Kahoot activity, where they not only participated actively but also expressed a desire to play more.” (Observation Number 1, Date: 20th November, 2023).

The integration of diverse technological tools into the lesson has resulted in active participation from the students. Their participation varied based on the type of technological tools integrated. Consequently, their participation was observed at different stages, encompassing the beginning, middle, and end of the lesson. These distinct stages contributed to the formation of sub-themes, namely attentive observation, collaborative group work, and diverted attention throughout the lesson.

In the first sub-theme, attentive observation, the students consistently maintained focus on the content delivered through the smartboard. They attentively watched the video, animation, and other instructional materials. The researcher elaborated on this event as follows:

“In general, the students actively engaged in the lesson by attentively watching the video, animation, and the rest of the content delivered via the smartboard.” (Observation Number 1, Date: 20th November, 2023).

In the middle of the lesson, the integration of technological tools prompted students to collaboratively work together to accomplish their tasks. Notably, simulations were employed, leading the students to work in groups. During this phase, one student would read instructions aloud while others executed them on their laptops. This fostered a collaborative learning environment. The researcher documented this event as follows:

“During the collaborative simulation task, they worked together in groups, with one student reading the instructions while others executed them on their laptops. Even when not directly

involved in a task, the students' maintained their focus on both their laptops and the smartboard." (Observation Number 1, Date: 20th November, 2023).

Lastly, the sub-theme that the researcher expounded upon was diverted attention. Towards the end of the lesson, the students displayed behaviors in the classroom that indicated a lack of active participation in the ongoing lesson. After completing their simulation task, some students shifted their focus to unrelated activities on their laptops, such as minimizing the simulation window and surfing the web. This behavior led to a loss of focus on the lesson, with students neither paying attention to the instructional content nor to the teacher. The researcher detailed this observation as follows:

"However, there were instances where some students, after completing their assigned tasks, became fully engrossed in unrelated activities on their laptops. Unfortunately, during these times, their attention was diverted from the teacher and the ongoing lesson." (Observation Number 1, Date: 20th November, 2023).

3.1.3.4. Problems and challenges faced by students using technological tools

Under this theme, the researcher provided a detailed account of the observations made regarding the challenges faced by the students during the lesson integrated with technological tools. As expected, challenges and problems were anticipated in the instructional process. It is crucial to clarify that the problems discussed here pertain solely to the students and not the researcher. After the lesson, a student raised a concern about the speed of the laptop mouse. The researcher elaborated on this matter as follows:

"Throughout the lesson, no student was observed having any issues or challenges. However, at the end of the lesson, a student raised a concern about controlling the laptop's mouse. Specifically, the student mentioned that the mouse seemed slower than he preferred, but he was able to manage with it. He inquired whether there could be adjustments made to address this issue for our future lessons." (Observation Number 1, Date: 20th November, 2023).

3.1.3.6. Resolution of problems encountered

This theme expounded on the challenge raised by the student regarding the slower mouse functionality. While in the instructional setting, the researcher promptly investigated and resolved the issue by adjusting the cursor speed, ensuring optimal functionality. Furthermore, during the investigation of the problem, it was discovered that the concern raised by the student was not a problem regarding the functionality of the mouse; instead, it was related to the speed of the mouse. According to the student, the

mouse was not very fast for his liking. The researcher provided details on how he dealt with the situation, as follows:

“The issue regarding the laptop mouse not functioning optimally was investigated. Upon investigation, it was discovered that the problem stemmed from a setting related to the cursor speed. Subsequently, the speed of the cursor was adjusted to ensure it moved slightly faster than before, resolving the problem.” (Observation Number 1, Date: 20th November, 2023).

3.1.3.7. Impact of technological tools on the classroom environment

In order to integrate technological tools into the lesson, adjustments were made in the classroom to ensure the optimal benefit of the technological tools for the students. The adjustments made in the classroom due to the integration of technological tools into the lesson informed the development of the sub-themes, namely seating arrangement change and enhanced interaction and support. The initial adjustment involved changing the seating arrangement from traditional rows to group seating. The rationale behind this adjustment was to foster a collaborative learning environment among the students. Additionally, this change has facilitated interactive lessons and improved classroom management. The researcher provided further elaboration on this adjustment as follows:

“In response to the integration of technological tools into the lesson, the seating arrangement of the students was changed from rows to groups. This facilitated collaborative learning, allowing the students to engage in lessons and complete tasks using technological tools collectively. This change not only promoted a more interactive classroom environment but also streamlined classroom management. With attention and tasks focused on group activities rather than individual tasks, it became more efficient to oversee and guide the students.” (Observation Number 1, Date: 20th November, 2023).

Additionally, the changes made in the classroom have had a positive impact on the classroom dynamics among the students during the instructional process. The adjustments in student seating from traditional to group seating have also fostered collaborative work among the students, particularly evident during simulation activities and assessments. This changes enhanced peer support and interaction among students, resulting in active engagement, problem-solving, and task completion within the group setting. The researcher highlighted this impact as follows:

“Furthermore, the collaborative nature of the classroom, enhanced by the use of integrated technological tools, enabled the students to provide peer support. This was evident during the simulation tasks and the assessments on platforms like Wordwall and Kahoot, where the

students actively engaged in peer scaffolding, assisting each other in problem-solving and task completion.” (Observation Number 1, Date: 20th November, 2023).

3.1.4. Findings from the students’ exit tickets

After the science lesson, integrated with various technological tools, the students were encouraged to share their experiences through reflection journals in the form of exit tickets. In these exit tickets, the students documented a wide range of experiences, capturing their engagement with the lesson content, the integrated technological tools, the activities conducted, and their overall feelings about the learning experience. The students focused their reflections on the topic covered during the lesson. They delved into their interactions with the technological tools, describing the tools integrated into the lesson. Furthermore, their reflections encapsulated the activities carried out during the lesson, providing insights into their hands-on experiences. The students' general feelings about the entire experience were also articulated. It is essential to note that on this day, all the students were present except Student 6. Additionally, only Students 1, 2, 3, 7, and 8 opted to write the reflection journal. However, despite Students 4 and 5 being present during the lesson, they chose not to write the reflection journal. The reflections written by the students at the end of the lesson are presented below.

In Student 1's exit ticket, the student provided a summary of the lesson taught in class, focusing on the topic of forces and motion. The lesson delved into the concepts of balanced and unbalanced forces. While various technological tools were integrated into the lesson, Student 1's reflection did not explicitly mention any specific tools or activities. Instead, the student opted to highlight the core content of the lesson. It appears that Student 1 primarily captured their understanding of the forces and motion topic, perhaps indicating a stronger emphasis on the conceptual aspects rather than the technological tools utilized. The reflective entry suggests a focus on the lesson's theoretical content rather than the practical applications facilitated by the technological tools. The reflection of Student 1 is as follows:

“Today we learned about forces and motion. Force is measured by (N) Newton. We also found out that balanced forces are equal and opposite in direction. If a force is unbalanced, the object will move to the place with the most force. If an object is not moving, it doesn't mean that there are no forces acting on it. There is gravity and contact force.” (First Week's Exit Ticket of Student 1).

In Student 2's exit ticket, she offered an account of the technological tools integrated into the science lesson. Notably, she provided insights into the tools utilized at each stage of the lesson, spanning the beginning, middle, and end. The reflection underscored the cooperative dynamics fostered by these technological tools, emphasizing the collaborative nature of the lesson. Student 2 not only highlighted the functionality of the tools but also expressed a positive feeling about the overall experience. She characterized the lesson as enjoyable and expressed hope for more similar lessons in the future. This reflective entry stands out for its detailed exploration of the technological aspects and the student's genuine enthusiasm for the interactive and collaborative learning facilitated by these tools. The exit ticket of Student 2 is as follows:

"Dear diary, today was a great day. I had a lot of fun in the science lesson. Our teacher put us in different groups, and we each had a computer in front of us. The teacher told us what we'd do in the lesson and even played us a video to watch about the lesson. Then we watched an animation that made us understand how the experiment worked. And remember the computers I told you about? Well, the group played a simulation about the lesson to make us feel like we were doing the experiment, and even another simulation. And my favourite part was that we played learning games as a group. First, we played Wordwall, then we played Kahoot. I had a lot of fun, and I look forward to more fun lessons like this." (First Week's Exit Ticket of Student 2).

In Student 3's exit ticket, there was a slight misrepresentation in the use of the term "memorizing" regarding the initial phase of the lesson. In reality, this stage involved assessing the students' relevant prior knowledge before delving into the day's lesson. The student further detailed the classroom arrangement, highlighting the consistent grouping throughout the lesson on forces and motion. The mentioned technological tools were video, animation, and Kahoot, with a notable omission of simulations and Wordwall. Particularly noteworthy was the comprehensive account of Kahoot at the end of the lesson. Student 3 provided information on the assessment tool, including the number of questions, the format of answering, and the grading method employed. This meticulous breakdown offers valuable insights into the student's perception and understanding of the assessment tool's functionality. Below is the exit ticket of Student 3.

"In today's science lesson, we were memorising what we did in the previous lesson. But we didn't do it in the usual way. First, Mr. Numan gave us laptops, but before, he divided us into two groups. After we watched a video with an experiment, the topic was forces. Then Mr. Numan opened an animation of that experiment. Next, he explained to us some rules about the topic and also explained how to do calculations of balanced and unbalanced forces. Then

he showed us a game about unbalanced forces and what would happen to objects if the forces were unbalanced. After that, we did a game quiz, which was also about forces. After the quiz, we did Kahoot. There were two teams and 10 questions. In Kahoot, you have to answer questions about topics your teacher gives you. The fastest team wins. If you answer the question right, you get points, but if you answer the question fast and right, you get more points. There are also places and streaks. If the team has more points and a longer streak than the other team, it takes first place. I really liked that science lesson. I think we should do it more often.” (First Week’s Exit Ticket of Student 3).

In her exit ticket, Student 7 provided a succinct elaboration on the topic. Notably, the technological tools explicitly mentioned by the student were video and games. While the specific game types were not stated, it was Wordwall and Kahoot that were used during the assessment phase of the lesson. Of significance in Student 7’s exit ticket is the emphasis on her feelings about the entire lesson. She expressed a liking for the lesson, describing it as interesting and funny. These positive attributes aligned with the engaging and interactive nature of the technological tools integrated into the lesson. Student 7’s reflections underscored the enjoyable and entertaining aspects of the lesson, suggesting a positive impact attributed to the utilization of technology in the learning process. This is what Student 7 wrote in her exit ticket:

“In this lesson, we learned about balanced and unbalanced forces. And about friction and wind. I like this lesson. It was interesting and funny. After we watched a video, we made revisions, and after that, we started to play games. It was enjoyable. I like it.” (First Week’s Exit Ticket of Student 7).

In his exit ticket, Student 8 highlighted the enjoyable nature of the lesson, attributing it to the integration of various technological tools. Specifically, he explicitly mentioned the animation watched at the beginning of the lesson and the use of Kahoot during the assessment stage as key contributors to the fun and improved learning experience. Student 8’s reflection underscored the positive impact of these tools on his engagement and comprehension. The acknowledgment of the animated content for initiating the lesson and the interactive assessment through Kahoot suggests a student who not only recognizes the value of technology in enhancing the learning environment but also personally appreciates the dynamic and entertaining aspects it brings to the educational experience. Student 8’s exit ticket is presented below:

“Hello, today’s science lesson was extremely fun because we learned by using technology, which helps you learn better. Moreover, we watched an animation and played Kahoot, which made it more amazing.” (First Week’s Exit Ticket of Student 8).

3.1.5. Findings from questionnaire

The questionnaire, designed to gather insights from the students after the science lesson integrated with technological tools, involved three sections, each containing two questions. The first question in each section employed a rating scale ranging from 1 to 10, while the second question sought open-ended responses, capturing the students' perspectives on various themes during the lesson. The questionnaire had three sections, which served as themes. The rating scale part of the questionnaire was analyzed using tables and graphs, whereas the open-ended questions were analyzed descriptively. The predefined themes were as follows:

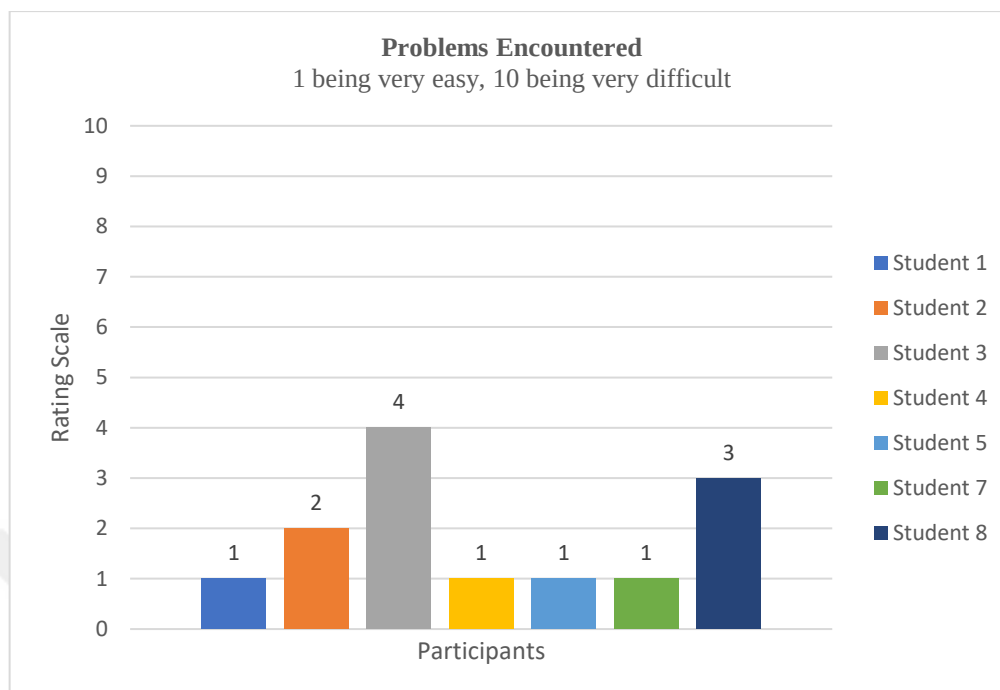
1. Problems Encountered
2. Technology's Contribution to Understanding
3. Enjoyment of the Lesson with Technology

3.1.5.1. Problems encountered

Under this theme, the problems encountered by the students during the lesson integrated with technological tools were elaborated. The questionnaire included a rating scale intended to unveil the difficulties faced by students, posing the question, "On a scale of 1–10, how would you rate the level of difficulty or problems you encountered during the lesson? (1 being very easy, 10 being very difficult)." Within this query, the students were not confined solely to articulating the problems they encountered but were also encouraged to express any circumstances that impeded their participation in the lesson. Table 8 presents the rating scale for the problems encountered by students during the first implementation.

Table 8. *Rating scale for the difficulties encountered by students during the first implementation*

Participants	Rating Scale									
	1	2	3	4	5	6	7	8	9	10
Student 1	✓									
Student 2		✓								
Student 3				✓						
Student 4	✓									
Student 5	✓									
Student 7	✓									
Student 8			✓							



Graph 1. *Difficulties encountered by students during the first implementation*

Table 8 and Graph 1 illustrate that only seven students actively participated in the lesson and subsequently completed the questionnaire. Student 6 was absent from school on the day of the implementation. The data from both the table and the graph revealed diverse ratings from the students regarding the problems they encountered during the lesson. Students 1, 4, 5, and 7 indicated that they did not encounter any problems or challenges during the lesson due to the integration of the technological tools. Students 2, 8, and 4 selected ratings of 2, 3, and 4, respectively, to express the level of difficulty or challenges they faced during the lesson. The specific reasons behind these ratings were provided in the second section of the questionnaire, which contained open-ended questions. The open-ended question was, “Describe any problems you encountered while having a science lesson integrated with technology.” Below are the responses provided by the students.

Student 1 expressed a positive understanding of the topic in the questionnaire. Despite the questionnaire requesting the students to describe any difficulties (problems) encountered during the science lesson integrated with technology, her response was positive. She highlighted that the simulation activity they carried out in the lesson contributed to her improved understanding of the topic. From this feedback, it can be

inferred that the student did not face any notable problems or challenges during the lesson. Her comment is elaborated below:

"I understand the topic well because we did a simulation about it." (Answer of Student 1 for the First Question of the First Week's Questionnaire).

Student 2's response to the problem she encountered during the lesson was actually about the behavior of one of the students in the class and had nothing to do with the integrated technological tool. This incident occurred during the assessment section of the lesson, where the students' answered questions on Kahoot. On Kahoot, the faster one answers a question, the more marks one gets. This might be the reason why Student 5 answered the questions too quickly. Other than this incident, Student 2 expressed that she did not face any problems or challenges regarding the technological tools integrated into the lesson. This is what Student 2 wrote in the questionnaire:

"The only problem was that Student 5 answered too fast sometimes, but it went well." (Answer of Student 2 for the First Question of the First Week's Questionnaire).

According to Student 3, on the problem she encountered during the lesson, she succinctly indicated that she did not encounter any problems and that everything was good. This is what she wrote in the questionnaire:

"I didn't have any problems; everything was really good." (Answer of Student 3 for the First Question of the First Week's Questionnaire).

Student 4 also provided positive feedback regarding the challenges encountered during the lesson. The student mentioned that he did not encounter any problems during the lesson due to the integrated technological tools. On the contrary, the technological tools made the lesson extremely easy. This is what Student 4 documented in the questionnaire.

"I didn't encounter problems in the lesson because we studied for forces and it was super easy." (Answer of Student 4 for the First Question of the First Week's Questionnaire).

Based on the comments provided by Student 5 regarding the challenges faced during the science lesson that incorporated various technological tools, it can be inferred that the student possessed a strong foundation of prior knowledge on the topic covered, which was forces and motion. According to Student 5, he had previously studied the same topic at his previous school. As a result, the topic became more manageable for him this time, and he did not experience any difficulties. Student 5 documented the following in the questionnaire:

"This is very easy because in my old school we did this unit." (Answer of Student 5 for the First Question of the First Week's Questionnaire).

Student 7 commented on the problems encountered during the lesson using the first-person plural. This can be associated with the fact that the students were in groups during the lesson and also used technological tools collaboratively. This suggests that Student 7 and her group members did not encounter any problems during the lesson, and the lesson was easy. This is what Student 7 documented in the questionnaire:

"We didn't have any problems. It was easy." (Answer of Student 7 for the First Question of the First Week's Questionnaire).

Out of the entire group of students who participated in the lesson integrated with technological tools, Student 8 was the sole individual who mentioned facing a challenge. The issue that Student 8 reported was related to the movement of the mouse, expressing dissatisfaction with its speed. This was the only problem he encountered, and he documented it in the questionnaire as follows:

"The mouse on the computer didn't work that well and was hard to use, but other than that, there was no problem." (Answer of Student 8 for the First Question of the First Week's Questionnaire).

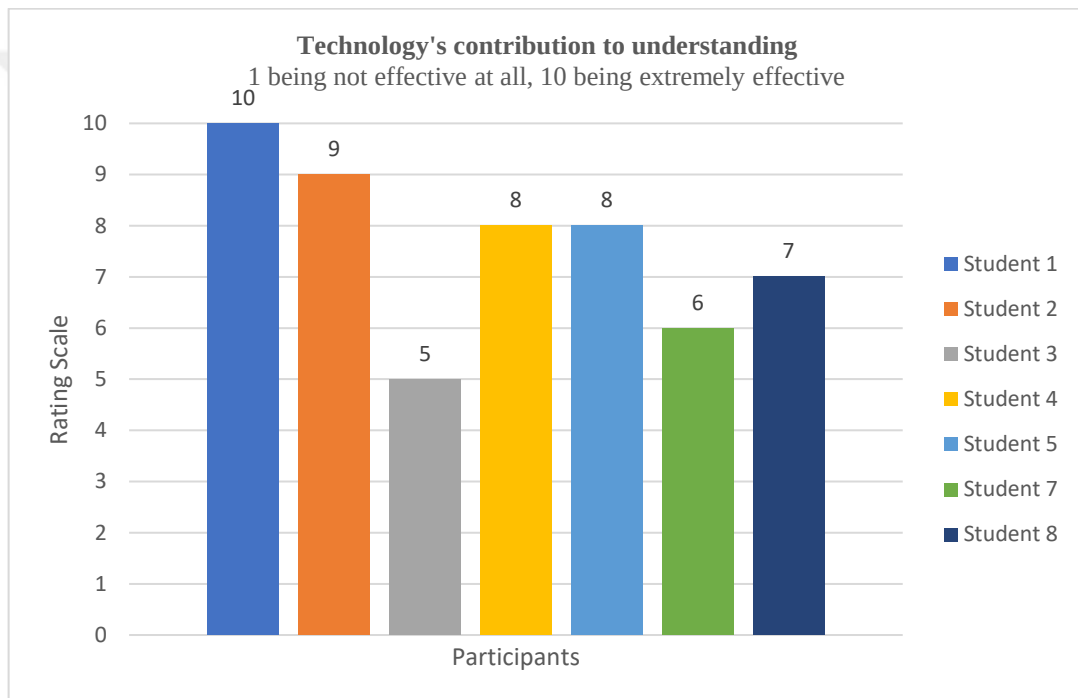
With the exception of one student, thus Student 8, all other students unequivocally conveyed a lack of problems encountered during the science lesson integrated with technological tools. All the students characterized the lesson as easy and comprehensible, attributing this to the simulations they engaged in and their existing knowledge of the topic. The single-mentioned issue pertained to the perceived slow movement of a mouse. The student found the mouse speed to be slow to their liking, and a simple adjustment addressed this concern. In a nutshell, excluding this isolated incident, the technological tools posed no challenges or problems for the students. The consensus among students is that the tools were easy to use, contributing to an overall positive experience in the science lesson integrated with technological tools.

3.1.5.2. Technology's contribution to understanding

This theme emphasizes the contributions made by the integrated technological tools to the students' understanding of the lesson. The questionnaire included questions designed to accentuate these contributions, incorporating both rating scales and open-ended questions. The rating scale prompts respondents with, "On a scale of 1–10, how effective do you think technology was in helping you grasp the concepts taught? (1 being not effective at all, 10 being extremely effective)." Table 9 displays the rating scale, illustrating technology's contribution to understanding.

Table 9. *Rating scale on technology's contribution to understanding during the first implementation*

Participants	Rating Scale									
	1	2	3	4	5	6	7	8	9	10
Student 1										✓
Student 2									✓	
Student 3					✓					
Student 4								✓		
Student 5								✓		
Student 7						✓				
Student 8							✓			



Graph 2. *Technology's contribution to understanding during the first implementation*

From Table 9 and Graph 2, it is evident that only Student 1 provided a perfect rating of 10/10, expressing that the technological tools integrated into the science lesson significantly contributed to her understanding of the scientific concepts taught. Student 2 also acknowledged a high contribution, giving it a rating of 9. On the other hand, Student 3 gave a rating of 5/10, indicating a certain level of uncertainty regarding whether the technological tools truly contributed to her understanding of the lesson. Students 4 and 5 both provided a rating of 8/10, suggesting a substantial positive impact on their understanding. Students 7 and 8 rated the contribution at 6 and 7, respectively. Notably,

none of the students rated below 5, implying that, to some extent, the technological tools integrated into the lesson contributed to their understanding of the science concepts taught.

The students shared diverse opinions on how the integration of technological tools into the science lesson contributed to their understanding of the science lesson. Their comments from the questionnaire are presented below.

Student 1 expressed that the integration of technological tools into the lesson significantly contributed to her understanding of the lesson. She elaborated that these tools, specifically animations and simulations, played a crucial role in making the lesson easier and more understandable. According to Student 1, the use of animations and simulations allowed for a visual representation of how experiments were conducted. Her comments on the questionnaire are presented below:

"It was easier for me to understand because I could easily see how the experiments were done with the animations and simulations." (Answer of Student 1 for the Second Question of the First Week's Questionnaire).

Student 2, in her comment, did not explicitly state whether the integrated technological tools had contributed personally to her understanding of the lesson. However, she generally elaborated on ways in which the integrated technological tools can contribute to the understanding of the lesson. In her written comment, she mentioned that the technological tool they used to conduct a virtual experiment resembled a real experiment, referring to the simulations used. Additionally, the technological tools provided clear examples and explanations and could be repeated whenever one desired, referring to the animations. Below is Student 2's comment on the questionnaire:

"It can resemble a real lab experiment, and it gave clear examples and explanations that you can even repeat if you don't understand." (Answer of Student 2 for the Second Question of the First Week's Questionnaire).

According to Student 3's comment on how the integrated technological tools contributed to her understanding of the lesson, she did not explicitly elaborate on how the tools specifically contributed to her understanding of the lesson. Instead, she provided feedback on the overall experience of the lesson. She characterized the lesson as being more interesting than usual, attributing this enhanced engagement to the integrated technological tools. This is what Student 3 wrote in the questionnaire:

"It was a little more interesting than usual lessons." (Answer of Student 3 for the Second Question of the First Week's Questionnaire).

Student 4 clearly highlighted how the integrated technological tools contributed to the understanding of the lesson. Initially, he acknowledged that the technological tools truly assisted in enhancing his understanding of the lesson. Furthermore, he described the integrated tools as having the capability to present the lesson content in a manner that is easily understandable. This is what Student 4 wrote in the questionnaire:

"It kind of helped because they explained it in an easier way for a person to understand the lesson." (Answer of Student 4 for the Second Question of the First Week's Questionnaire).

Student 5 expressed that the integrated technological tools in the lesson significantly contributed to his understanding of the lesson content. He further specified questions as one of the tools that facilitated his learning. It can be inferred that by "questions," he was referring to tools like Wordwall and Kahoot, which were integrated during the assessment phase of the lesson. Additionally, his mention of games likely pertained to the interactive features of Wordwall and Kahoot. Student 5 documented this in the questionnaire:

"It helped me because there were questions and some video games, and it helped me understand." (Answer of Student 5 for the Second Question of the First Week's Questionnaire).

Student 7 confidently affirmed her comprehensive understanding of all the lessons, attributing this success to the integrated technological tools. She emphasized that these tools were not only informative but also incorporated an element of humour into the learning experience. In her questionnaire response, Student 7 acknowledged the dual impact of the integrated tools, enhancing both understanding and engagement through their informative and entertaining qualities. This is what Student 7 recorded in her questionnaire entry:

"I think technology helped us. It was informative and, at the same time, funny. I understand all." (Answer of Student 7 for the Second Question of the First Week's Questionnaire).

Student 8 succinctly conveyed that the integration of technological tools significantly contributed to his understanding of the lesson. According to him, the primary purpose of incorporating these tools into a lesson is to enhance students' understanding, and he attested to their success in achieving this objective. He further highlighted specific technological tools, thus animation, noting its collective role in enhancing his understanding of the lesson. Student 7 documented this in the questionnaire:

"It made me understand the lesson because technology makes you understand better (animation, etc.)." (Answer of Student 8 for the Second Question of the First Week's Questionnaire).

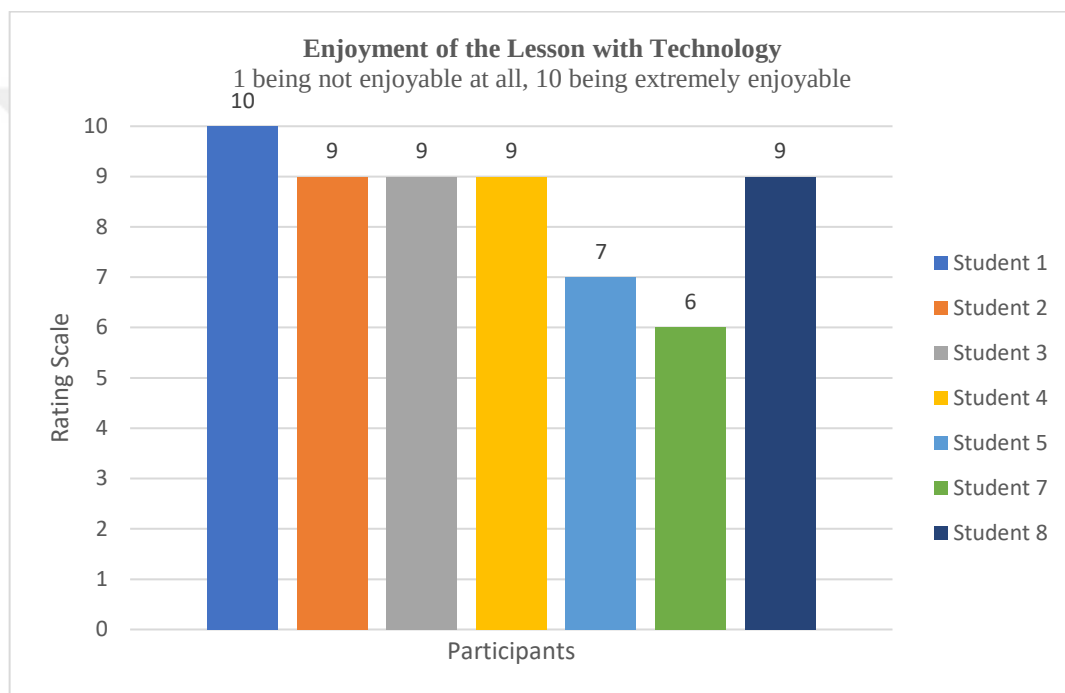
All the students unequivocally expressed that the integration of technology significantly contributed to their understanding of the science lesson. A recurring theme in their comments was the profound impact of the integrated technological tools on enhancing their understanding. Several students attributed their enhanced understanding to the interactive nature of simulation activities, underscoring that these virtual experiences provided a real-world context, fostering a more immersive learning experience. Additionally, the students specifically praised the role of animations in simplifying instructions, emphasizing how this visual aid contributed to their clarity of understanding. The consensus among the students was clear: the integrated technological tools, through interactive simulations and instructive animations, have undeniably played a pivotal role in enhancing their overall understanding of the science lesson. The positive feedback from the students reinforced the notion that technological tools are valuable educational resources that enhance students' understanding during the instructional process.

3.1.5.3. *Enjoyment of the lesson with technology*

This theme highlights how the science lesson was made enjoyable for the students by the integrated technological tools. In order to solicit information from the students on this topic, the questionnaire made a provision for the students to rate the enjoyment level of the lesson as a result of the integrated technological tools on a scale of 1–10 and also express their views in writing on how the technological tools made the lesson enjoyable. With the rating scale, the question asked was, “On a scale of 1–10, how would you rate your overall enjoyment of the lesson? (1 being not enjoyable at all, 10 being extremely enjoyable).” Table 10 displays the rating scale, illustrating enjoyment of the lesson with technology during the first implementation.

Table 10. *Rating scale on the enjoyment of the lesson with technology during the first implementation*

Participants	Rating Scale									
	1	2	3	4	5	6	7	8	9	10
Student 1										✓
Student 2									✓	
Student 3									✓	
Student 4									✓	
Student 5							✓			
Student 7						✓				
Student 8									✓	



Graph 3. *Enjoyment of the lesson with technology during the first implementation*

From Table 10 and Graph 3, it is evident that the students have provided varying ratings on how the integrated technological tools enhanced the enjoyment of the science lesson. According to this data, only one student gave a perfect rating of 10, indicating that the integrated technological tools significantly increased her enjoyment of the lesson. Students 2, 3, 4, and 8 gave a rating of 9, while Students 5 and 7 rated 7 and 6, respectively. Importantly, none of the students rated below 6, underscoring that the technological tools integrated into the lesson indeed contributed to the overall enjoyment of the science lesson.

The second section of the questionnaire posed an open-ended question, prompting the students to elaborate on how the integrated technological tools enhanced their enjoyment of the lesson. The questionnaire prompt was, "In your opinion, how does the integration of technology in science lessons enhance the overall enjoyment of the learning experience?" The students offered diverse opinions on this matter, and their comments from the questionnaire are presented below.

Student 1 asserted that the integration of technological tools into the lesson heightened the enjoyment of the learning experience. She specifically attributed this enhanced enjoyment to the interactive games incorporated in the lesson. Moreover, Student 1 highlighted that the technological tools contributed to making the lesson easier and more understandable for her. Additionally, she expressed that the collaborative approach employed in executing the game tasks added to the overall fun of the lesson. This is what Student 1 wrote in the questionnaire:

"It was more fun because we played games about it, and it was easier for me to understand. Also, the games were more fun with group work." (Answer of Student 1 for the Third Question of the First Week's Questionnaire).

Student 2 expressed that the integrated technological tools significantly increased her overall enjoyment of the lesson. She specifically attributed this enjoyment to the simulation tasks conducted during the lesson. Furthermore, Student 2 emphasized that the technological tools contributed to enhancing the clarity of the lesson, making it very clear for her. Additionally, she acknowledged that these tools played a crucial role in contributing to her understanding of the lesson. Student 2's feedback, as outlined in the questionnaire, underscores the positive impact of the integrated technological tools on both enjoyment and understanding of the lesson.

"It contained fun simulations that were easy to understand and enjoyable. It was very clear to me and helped my understanding." (Answer of Student 2 for the Third Question of the First Week's Questionnaire).

Student 3 provided a brief account of the conclusion of the lesson without explicitly emphasizing how the integrated technological tools contributed to the overall enjoyment of the learning experience. Student 3 used the terms "remembering" and "memorizing" to characterize the activities at the end of the lesson. In reality, a lesson summary was conducted, encompassing the review of all topics, addressing the students' queries, and assessing the students' understanding of the lesson content utilizing Wordwall and Kahoot. It can be inferred from Student 3's comment that she particularly enjoyed the

assessment segment of the lesson involving Kahoot and expressed a desire for its more frequent incorporation. This is what she wrote in the questionnaire:

"We are remembering and memorising everything we did in the previous lesson, but I think we could do more Kahoot." (Answer of Student 3 for the Third Question of the First Week's Questionnaire).

Student 4 characterized the science lesson, integrated with technological tools, as enjoyable. Student 4 attributed the enjoyable nature of the lesson to the various activities carried out with different technological tools. It can be inferred from Student 4's comment that, by "different types of stuff," they are actually referring to the video and animation watched at the beginning of the lesson, the simulations from Olabs and PhET conducted in the middle of the lesson, and the use of Wordwall and Kahoot during the assessment section. Student 4 believed that these elements were what made the lesson enjoyable. This is what Student 4 penned down in the questionnaire:

"It was enjoyable because we had different types of stuff to do." (Answer of Student 4 for the Third Question of the First Week's Questionnaire).

Student 5 explicitly characterized the lesson as enjoyable, attributing this positive experience to the games played during the lesson. These games were incorporated into the assessment phase, utilizing platforms like Wordwall and Kahoot to evaluate the students understanding of the lesson. Additionally, Student 5 characterized the lesson as fun, signifying that the integration of the technological tools into the science lesson had not only enhanced the overall enjoyment of the learning experience but had also made the lesson inherently entertaining. This is what Student 5 recorded in the questionnaire:

"It was enjoyable because we played games and we learned [about] Newton, and it is fun." (Answer of Student 5 for the Third Question of the First Week's Questionnaire).

Student 7 shared her opinion that, in her view, the technological tools integrated into the science lesson significantly contributed to the enjoyment of the lesson. She specifically attributed the enjoyable nature of the lesson to the integration of Wordwall and Kahoot at the assessment phase. Additionally, Student 7 characterized the overall lesson as funny. This sentiment, as expressed in her questionnaire response, highlighted the positive impact of the integrated technological tools, particularly Wordwall and Kahoot, on making the learning experience enjoyable for her. This is what she recorded in the questionnaire:

"In my opinion, it was enjoyable. We have some games, such as Kahoot and Wordwall. It was funny." (Answer of Student 7 for the Third Question of the First Week's Questionnaire).

Student 8 conveyed that the integration of technological tools into the lesson contributes to the overall enjoyment of the learning experience. He associated this sentiment with the notion that technological integration resembles a game, and consequently, it enhances the enjoyment of the lesson. Furthermore, Student 8 emphatically concluded that the utilization of technology in the lesson is extremely enjoyable. This insight, documented in his questionnaire response, underscores the positive impact of integrating technological tools, highlighting the association between technology, gamification, and the enhanced enjoyment of the lesson. This is what Student 8 recorded in the questionnaire;

“Using technology makes enjoyment because it is like a game and it is very fun to use. So, using technology is extremely enjoying.” (Answer of Student 8 for the Third Question of the First Week’s Questionnaire).

The collective feedback from the students consistently reflected positive sentiments regarding how the integration of technological tools enhanced the overall enjoyment of the science lessons. Notably, all students acknowledged that technology significantly contributed to the enjoyable nature of the learning experience. A prevalent theme among the students' views was the positive impact of games, particularly Wordwall and Kahoot, which were actively employed during the assessment stage of the lesson. Moreover, several students highlighted that the integration of technological tools not only increased the enjoyment of the lesson but also had ancillary benefits. Some students expressed that these tools made the lesson easier to navigate and significantly enhanced their understanding of the material. In summary, the students' comments collectively indicated that the integrated technological tools, especially through the incorporation of engaging games, have successfully achieved the goal of making the science lessons enjoyable. This positive feedback aligned with the intended purpose of integrating these tools into the science lesson.

3.1.6. Findings from semi-structured focus group interview

Following the science lesson integrated with various technological tools, the students' feedback was gathered through a semi-structured, focused group interview. Descriptive analysis, which involves the examination of data using themes, was employed for analyzing the findings from the interview. The interview questions were instrumental in guiding the development of themes and sub-themes for analysis. Table 11 outlines the

emergent themes and sub-themes from the semi-structured interview, providing a foundation for in-depth analysis.

Table 11. *Themes and sub-themes emerged from the semi-structured interview during the first implementation*

Themes	Sub-Themes
1. Lesson Content	Balanced and Unbalanced Forces Newton's Third Law of Motion Calculating Net Force
2. Utilization of Technological Tools	Types of Technological Tools Used Stages of Tool Usage
3. Problems Encountered	Lack of Problems Minor Technical Issue
4. Students' Views on the impact of Technology Integration in Science	Performance Improvement Fun Learning Enhanced Understanding More Engagement
5. Student Inquiries and Additional Comments	Student Questions Advocacy for Continued Integration

3.1.6.1. Lesson content

This theme emphasizes the subject matter addressed in the science lesson, incorporating diverse technological tools. The sub-theme outlines the specific topics covered throughout the lesson, encompassing the essential learning objectives and subject matter explored, which was forces and motion. The students articulated this during the interview as follows:

TEACHER: *Okay, so good afternoon to you all. So, we are going to have our interview. The interview is going to be about the lesson we had by integrating different technological devices into the science lesson. So, I have some questions for you. So, let's begin with the first question: What did you learn in class today? What was the topic?*

Student 1: *We learned about forces and motion; we learned about balance and unbalanced forces. And Newton's third law of motion. And lastly, calculating the net force.*

Student 5: *Forces and motion, balanced and unbalanced force, Newton's Third Law of Motion, and calculating net force.*

3.1.6.2. Utilization of technological tools

This theme emphasizes the integration of various technological tools into the science lesson. The sub-themes provide insights into the specific types of technological tools incorporated, such as video, animation, simulations, Wordwall, and Kahoot. The second sub-theme delves into the different stages of the lesson where the tools were

integrated, categorizing the technological tools used at the beginning, middle, and end of the session. The interview between the teacher and students unfolded in this manner.

TEACHER: *Thank you very much. So next, what technological tools did you use in the lesson?*

Student 1: *We watched a video, an animation, a simulation, another simulation, Wordwall, and Kahoot.*

TEACHER: *When were these technological tools used in the lesson? At the beginning of the lesson, which technological tools did you use?*

Student 7: *The video and the animation were used in the beginning.*

Student 5: *Videos and animation.*

Student 8: *Video and animation*

TEACHER: *Student 7, what about in the middle of the lesson?*

Student 7: *In the middle was a simulation, and we also played some games [inaudible], like Wordwall and Kahoot.*

TEACHER: *The Wordwall and Kahoot, were they used in the middle of the lesson or at the end of the lesson?*

Student 7: *At the end of the lesson.*

TEACHER: *Student 3, in the middle of the lesson, what technological tools did we use?*

Student 3: *A simulation from OLABS and a simulation from PhET.*

TEACHER: *Okay, thank you. And finally, at the end of the lesson, what technological tools did we use?*

Student 5: *We used Wordwall and Kahoot.*

TEACHER: *Okay. Student 4?*

Student 4: *Wordwall and Kahoot.*

Student 8: *Wordwall and Kahoot.*

3.1.6.3. Problems encountered

This theme focuses on the challenges encountered during the science lesson integrated with technological tools. After the lesson, the majority of the students reported that they did not encounter any problems, indicating a seamless integration of the technological tools into the lesson. This forms the first sub-theme. The second sub-theme, minor technical issues, highlights a specific challenge where one student experienced a minor problem with the slow movement of the mouse during the lesson.

TEACHER: *Okay. Thank you very much. So, the next question we are going to look at is about the problems we encountered. So, during the lesson, did you encounter any problems related to the technological tools we used?*

Student 2: *I don't think so. No, it was completely fine.*

TEACHER: *Okay. Student 1, what about you?*

Student 1: *I didn't face any problems.*

TEACHER: *Student 3, what about you?*

Student 3: *I didn't have any problems.*

TEACHER: *Student 4, what about you?*

Student 4: *No.*

TEACHER: *Student 8?*

Student 8: *Like, the mouse was, erh, the mouse didn't work. It worked, but it was hard to use.*

3.1.6.4. Students' views on the impact of technology integration in science

This theme sheds light on the various views and perceptions the students expressed about the integration of technology in the science teaching and learning process. The first sub-theme “Performance Improvement” underscores the positive impact of the technological tools reported by the students, which led to their improved grades and enhanced performance.

TEACHER: *The next question is: has there been any change in your grades or performance since we started using the technological tools and equipment in the class? But the thing is, this was our first time using these technological tools. So, the performance will have to do with the grades you got in the Wordwall and in the Kahoot. Was it improved? Are you happy with it?*

Student 3: *Yeah.*

TEACHER: *Okay, so let's let me begin with you. How were the performance and grades as a result of the technological tools we used?*

Student 2: *Um, I think the performance was great and better than last time. I think that the grade is good. Very good.*

TEACHER: *Okay, thank you very much. Student 1, what about you?*

Student 1: *I think it actually improved because I was able to learn with my friends because we were in a group, and it helped me understand a lot better.*

TEACHER: *Thank you very much. Student 7, what about you?*

Student 7: *I think the technology is much better than writing this more informative.*

TEACHER: *Okay. Student 3?*

Student 3: *It helped me understand better, and it was more interesting, and I think I kind of improved.*

TEACHER: *Student 5?*

Student 5: *Because simulations and animations help, like helping to understand.*

TEACHER: *Okay, so how did it make you better in your performance?*

Student 5: *I understand better because they're showing how forces and motions work and how they're working.*

TEACHER: Okay, thank you very much. Okay. Now, back to the performance and the grades, how did the technological tools we used help in the performance and grade? We can talk about the Kahoot and also the Wordwall.

Student 4: Kahoot helped me because it was challenging, and while at that, you also knew the question and knew what the answer was because you studied for it a lot.

TEACHER: Okay. Student 8?

Student 8: Technology helped me get better grades because, for example, with Kahoot, if there is a question you don't know, you learn new things from Kahoot. And from animations and simulations, you see, erh, it helps you memorise it better. So yeah.

TEACHER: Student 3, what about you? How did the technological tools that were used in class make you feel?

Student 3: It was more interesting, and we repeated what we did in the in the previous lesson.

TEACHER: And we repeated what we did in the previous lesson. Can you explain a little bit further?

Student 3: So, when we watched the video, I understood the experiment better. And when we did the simulation, I also understood better.

The second sub-theme, “Fun Learning” underscored how the students perceived the technological tools as contributors to an enjoyable and fun lesson experience.

TEACHER: How did the use of technological tools in class make you feel? Let's begin with Student 2. How did the technological tools in the science lesson make you feel?

Student 2: I think, I feel, um, I don't know, I feel normal about them. They enhanced my learning. Because it's like in a way that isn't just writing, is in a way that I have more fun with, and also is a way that I'm more comfortable with, so [inaudible].

TEACHER: Student 1, how did the use of technological tools in class make you feel?

Student 1: Well, they helped me understand better because I was easily able to see the experiment from the simulations and animations. And it affected me in a good way.

TEACHER: Okay. Thank you. Student 7, what about you? The technological tools we used—how did they make you feel in the class?

Student 7: I feel good and funny because, like some games, it was also like a lesson, but in the lesson, we were sitting in a group, it was funny and informative.

TEACHER: The final thing we are going to look at is, what do you think about the use of technological tools in science lessons?

Student 2: I think they would improve the grade and performance of the student better because it is more fun than just working on the book. And I feel like, as soon as we did it with friends, it would also be a lot more enjoyable that way. So, I think I encourage it.

TEACHER: Okay. Thank you very much. Student 1, what do you think about the use of technological tools in science lessons?

Student 1: *I think it's a lot better that way. It's more enjoyable for me and my friends. I was able to learn with my friends, and I could see the experiment easily and how it's done.*

TEACHER: *Thank you very much. Okay, Student 3, what do you think about using technological tools in science lessons?*

Student 3: *It was more interesting. And I think we should do more Kahoot.*

TEACHER: *Student 5, what do you think?*

Student 5: *It's good.*

TEACHER: *Okay. Student 4?*

Student 4: *It's fun, and it's good. It's a fun way to learn.*

TEACHER: *Okay. Student 8?*

Student 8: *It's fun. It's nice. It helps you learn better. Yeah.*

TEACHER: *So finally, should we continue to use technological tools in the lesson, or should we not use technological tools in the lesson?*

Student 4: *Yes, we should.*

Student 8: *Yes.*

TEACHER: *Okay. So, Student 5, why should we continue to use technological tools in the lesson?*

Student 5: *Because it's helping to learn fast, like, it's helping to learn. Yeah.*

TEACHER: *Okay. Student 4, what do you think? Should we continue to use technological tools? Or should we stop using technological tools?*

Student 4: *Yes, we should start using it. Because it will be a fun experiment, erh, experience to do all of that.*

TEACHER: *Okay. Student 8?*

Student 8: *Yes. Because, like, as Student 4 said, it's for me to experience, and I think it's a better way to learn.*

The third sub-theme “Enhanced Understanding” elucidates the students' perspectives on the impact of integrated technological tools on their understanding of the lesson. Additionally, it emphasizes how the integrated technological tools significantly enhanced the comprehension and expanded the knowledge of the students. The final sub-theme “More Engagement” delves into the engagement aspect of the lesson, highlighting how the tools made the lesson fun, aided visualization through animation, and contributed to effective learning engagement. The sub-themes collectively conveyed the positive influence of the technological tools on both the understanding and the overall learning experiences of the students.

TEACHER: *What impact did the technological tools used in the course have on your understanding of the course? How did the technologies make you understand the course?*

Student 4: *It helped a lot. And it made better experience in teaching. And we had a lot of fun. Also, from that, we learned a lot.*

TEACHER: Okay. Student 8, what do you think?

Student 8: And also, animations helped us see and visualise it better. And in a fun way. So, it was nice.

TEACHER: It was nice. Okay, what can you say about the Kahoot we played?

Student 5: I liked it. I love Kahoot. Like, it's helping to learn.

3.1.6.5. Student inquiries and additional comments

This sub-theme highlights instances where the students made inquiries during the interview about the integrated technological tools in the science lesson. The students were curious about when they could engage in a more Kahoot activity, showcasing their interest and enthusiasm for the interactive learning experience. The teacher responded by indicating that Kahoot would likely be incorporated into the next lesson. This sub-theme underscores the students' proactive engagement in the learning process, seeking clarification and expressing anticipation for specific activities, thus playing Kahoot. In the second sub-theme, the students advocated for the continued integration of technological tools into the science lesson. The responses of the students towards the integration of technological tools into the science lesson were affirmative, and the students also cited reasons like believing the tools helped them learn quickly, made the lesson enjoyable, and contributed to a better learning experience.

TEACHER: Okay. Thank you all. Do you have any questions or something you would like to make clear about the questions I asked you?

Student 5: When can we play Kahoot?

Student 3: When are we going to do Kahoot?

TEACHER: I think probably in our next lesson, we'll do Kahoot. In Shaa Allah. Okay. Any question? Okay, thank you all for your contribution.

TEACHER: So finally, should we continue to use technological tools in the lesson, or should we not use technological tools in the lesson?

Student 4: Yes, we should.

Student 8: Yes.

TEACHER: Okay. So, Student 5, why should we continue to use technological tools in the lesson?

Student 5: Because it's helping to learn fast, like, it's helping to learn. Yeah.

TEACHER: Okay. Student 4, what do you think? Should we continue to use technological tools? Or should we stop using technological tools?

Student 4: Yes, we should start using it. Because it will be a fun experiment, erh, experience to do all of that.

TEACHER: Okay. Student 8?

Student 8: Yes. Because, like, as Student 4 said, it's for me to experience, and I think it's a better way to learn.

3.1.7. Findings from the researcher's post-implementation reflection journal

After the science lesson integrated with technological tools, the researcher solicited various forms of data from both himself and the students to assess the lesson and gain insights into the effectiveness of the integrated technological tools. Following the collection of this data, the researcher wrote a post-implementation reflection journal, detailing his perspective on the lesson's execution with the technological tools and the outcomes. The data from the researcher's post-implementation reflection journal were categorized into themes and analyzed descriptively. Here are the themes that emerged from the researcher's post-implementation reflection journal:

1. Attainment of Instructional Goals Through Effective Technology Integration
2. Effective Integration of Technological Tools for Enhanced Learning
3. Effective Assessment through Interactive Games and Positive Student Engagement
4. Students' Feedback on Technology Integration
5. Encountered Problems and Solutions

3.1.7.1. Attainment of instructional goals through effective technology integration

Under this theme, the researcher highlighted the successful execution of the science lesson, fully integrated with various technological tools. Despite facing some minor challenges during the lesson, the researcher considered the lesson a success. Furthermore, the researcher expressed confidence in achieving the overall objective of the lesson, which was to enhance his instructional practices and use technology to improve students' understanding of science concepts. The post-implementation reflection journal entry recorded by the researcher in this regard reads as follows:

"I am delighted to share that I have successfully executed my first science lesson, fully integrated with technology. Despite encountering challenges during the implementation, I consider it a success. The primary goal of this implementation was to enhance my teaching practice by integrating technological tools into my science lesson. I aimed to explore effective ways of integrating these tools and understand how they could enhance students' understanding of key scientific concepts. Based on my observations, as well as the performance and feedback received from students through the assessment tools,

questionnaires, and interviews, I can confidently say that my objectives for the implementation have been achieved.” (Ankara, 20th November, 2023, Line Number: 1-8).

3.1.7.2. Effective integration of technological tools for enhanced learning

This theme highlights the successful integration of various technological tools into the science lesson. The researcher expressed that the technological tools that were intended to be integrated into the lesson, which included a video, animation, simulations, Wordwall, and Kahoot, were actually able to be successfully integrated into the lesson. Additionally, the researcher gave a brief description of how effective the integrated technological tools turned out to be. He characterized the integrated technological tools positively and expressed that the tools fostered active and cooperative learning among the students, which contributed to the overall success of the lesson. This is what the researcher recorded in the post-implementation reflection journal:

“During the lesson, I successfully integrated all the planned technological tools, including a video, an animation, two simulations, Wordwall, and Kahoot. From my observations, the video provided a concise and effective explanation of the lesson, contributing to a better understanding for the students. Additionally, the animation proved to be a valuable resource, offering a straightforward yet insightful step-by-step guide for carrying out the simulation task. The students actively and cooperatively engaged in the simulation tasks, leading to a successful implementation. Observing their responses, it was evident that the students not only understood the tasks well but also really enjoyed them. Their enthusiasm and full engagement during the tasks reflected a positive learning experience.” (Ankara, 20th November, 2023, Line Number: 9-17).

3.1.7.3. Effective assessment through interactive games and positive student engagement

This theme highlights the successful execution of the assessment of the lesson through the utilization of interactive games, specifically Wordwall and Kahoot. Additionally, the theme focuses on how these assessment activities were effective in assessing the students' understanding, as evidenced by their excellent performance with perfect scores and positive engagement. The students not only demonstrated a thorough understanding of the lesson, but they also expressed enjoyment and a desire for more interactive games. The positive engagement and the students' request for more games underscored the success of using interactive assessments to reinforce their comprehension

of the lesson. This is what the researcher recorded in the post-implementation reflection journal:

“During the assessment stage of the lesson, the students participated in Wordwall and Kahoot. Based on my observations, the students demonstrated excellent performance, as reflected in their scores, indicating a thorough understanding of the lesson. Both groups achieved perfect scores of 5/5 in the Wordwall and impressive scores of 9/10 in the Kahoot. Notably, the first group secured the top position on the Kahoot scoreboard, answering questions more swiftly than the second group. From my observations, the students really enjoyed the interactive games and expressed a desire for more. Unfortunately, due to time constraints, we couldn't extend the game session further. The positive engagement and request for more games underscored the success of the assessment activities in reinforcing their understanding of the lesson.” (Ankara, 20th November, 2023, Line Number: 18-26).

3.1.7.4. Students' feedback on technology integration

This theme centers on the valuable feedback gathered from the students following the integration of technological tools into the science lesson. The solicitation of feedback involved a structured questionnaire and reflections, providing a quantitative measure of perceived ease, effectiveness, and enjoyment of the science lesson. Subsequently, in-depth interviews delved into various aspects, including tool usage, impact on understanding, emotional responses, encountered problems, and overall views on technology integration. The collected feedback revealed predominantly positive feelings, emphasizing enhanced understanding, cooperative learning, and an enjoyable learning experience. Despite a minor issue with a laptop's mouse speed, the overall outcome aligned with expectations, showcasing the depth and richness of student perspectives on science lessons integrated with various technological tools. This is what the researcher wrote in the post-implementation reflection journal in that regard:

“After the lesson, I gathered valuable insights from the students regarding their opinions and experiences with the integration of technological tools into the science lesson. I employed a questionnaire consisting of three questions, focusing on the problems they encountered, how the technological tools contributed to their understanding, and their overall enjoyment of the lesson. The least feedback received on a scale of 1–10, where 1 signified "very easy" and 10 denoted "very difficult," for the problems encountered during the lesson was 4. Additionally, on a scale of 1–10, where 1 represented "not effective at all" and 10 indicated "extremely effective," the least feedback given on technology's contribution to understanding the lesson was 5. Furthermore, on a scale of 1–10, where 1 meant "not enjoyable at all" and 10 meant "extremely enjoyable," the least feedback received for the enjoyment of the lesson with

technology was 6. In addition to numerical responses, the students provided written reflections in the questionnaire and reflection journals in the form of an exit ticket, offering insightful accounts of how the integrated technological tools enhanced their understanding of the lesson.

Moreover, the students were interviewed to delve deeper into their experiences, focusing on which technological tools were used, how they were utilized, the impact of these tools on their understanding, emotional responses to the technology, encountered problems, the influence on their performance, and their general views on the integration of technological tools into the science lesson. This comprehensively collected feedback provided a more nuanced understanding of the students' perspectives and experiences with the science lesson integrated with various technological tools. Generally, the students gave positive expressions, expressing that the tools really enhanced their understanding of the lesson and fostered cooperative learning. The lesson was enjoyable, and they did not face any problems. However, only one student expressed facing a problem with the speed of the mouse he was using after the lesson. Other than that, everything went as anticipated." (Ankara, 20th November, 2023, Line Number: 27-50).

3.1.7.5. Encountered problems and solutions

This theme revolves around the challenges encountered during the implementation of technology-integrated science lessons. The researcher, despite facing challenges such as time constraints, techno-centric distractions, and excessive technology integration, successfully managed some of the challenges and devised plans to address others in subsequent lessons. The challenges, while posing temporary setbacks, became valuable learning experiences. The researcher's proactive approach involved interventions to minimize distractions and redirect students' focus. Reflecting on these challenges, the researcher gained insights that will inform future lessons, emphasizing the need for a more streamlined and effective integration of technological tools. This is what the researcher recoded in the post-implementation reflection journal:

"I did encounter some challenges during the implementation. Addressing them in the classroom, I successfully managed a few while devising plans to tackle the rest before my subsequent lesson. Lack of time was a prominent challenge. Despite my initial plan to seamlessly integrate technological tools and collect feedback from students, the constraints of time prevented me from executing this part of the plan effectively. Techno-centric distractions emerged as another obstacle. The students became so engrossed in the technological tools that their focus shifted away from the teacher and the core lesson content. In response, I intervened by minimizing distractions and redirecting their attention back to the lesson. Excessive technology integration was also noted as a challenge. The array of

technological tools integrated into the lesson seemed to be overwhelming within the given time frame. This realization prompted me to reflect on a more streamlined approach for subsequent lessons. These challenges, while present, served as valuable learning experiences. They have informed my plans for future lessons, ensuring a more refined and effective integration of technological tools.” (Ankara, 20th November, 2023, Line Number: 51-63).

3.1.8. Findings from the validity committee meeting records

After each lesson, the researcher collected a series of data about how the lesson went, focusing particularly on the problems encountered and how these problems were addressed. Subsequently, a meeting was convened with the validity committee members to deliberate on the problems encountered during the lesson and propose solutions. Table 12 outlines the problems identified by the validity committee according to the collected data during the first implementation and the decisions made by the validity committee members to address them.

Table 12. *First Implementation Issues and Validity Committee Decisions*

Related Week	Encountered Problems	Action Decisions Taken to Solve Problems	VCM		
			No:	Mins	P
1 st Week	There was an issue of techno-centric distractions, wherein students completed their simulation task and became overly engrossed in unrelated activities on their laptops.	The simulation task should be made slightly more challenging for the students to ensure they spend an adequate amount of time on it.	1	90	4
	Some students provided conflicting responses to the questionnaire.	The questionnaire should be reviewed before conducting the interviews in order to probe and gather more detailed responses from the students in such cases.			
	The individual students were not assessed.	The assessment of the lesson should be conducted individually using a variety of technological tools.			
	Due to time constraints, the implementation was not able to be completed within the specified time frame.	A technology integration timeline outlining the activities to be carried out and their scheduled times should be developed.			
	The problem of excessive technology integration arose due to the use of multiple technological tools, including a video, animation, two simulations, Wordwall, and Kahoot. This issue also contributed to time constraints.	Only one tool should be integrated during the assessment phase, either Kahoot or Wordwall. Additionally, only one or two simulations should be used. It is not necessary to integrate too many tools.			

VCM: Validity Committee Meeting; No: Meeting No; Mins: Meeting Duration (Minutes); P: Number of Participants

According to Table 12, from the observations made by the researcher during the lesson, techno-centric distractions were noted. This problem arose when the students completed the simulation task assigned by the teacher and engaged in activities unrelated to either the simulation tasks or the science lesson. The students were observed opening new windows on their laptops and surfing the internet. During this encounter, the students were deeply immersed in surfing the internet and were not paying attention to either the teacher or the lesson. At that particular moment, the researcher, who also served as the teacher, closed the students' laptops, prompting them to refocus and pay attention to the lesson. During the validity committee meeting, validity committee member 2 suggested that perhaps the simulation tasks given to the students were too easy, leading them to complete the tasks quickly and engage in unrelated activities. Validity committee member 2 suggested giving the students a challenging task. This is what validity member 2 said during the meeting:

“It's all very easy. While performing the simulation, students open windows. This came very easily to the children. Should we make it a little harder? If it is that easy, there is a problem. There needs to be some challenge for learning.” (VCM No. 2).

Validity committee member 2 recommended that in subsequent lessons, challenging simulation tasks should be selected for the students to ensure they spend more time on the task, preventing them from finishing quickly and diverting to unrelated activities.

During the validity committee meeting, it was noted that some students provided conflicting feedback on the questionnaire they filled out after the lesson. Two students did not give a high rating on the rating scale of the questionnaire, indicating some dissatisfaction. However, when it came to the written section, where they were asked to elaborate on their ratings, the students unexpectedly gave positive responses, creating a contradiction in their overall feedback. For instance, when addressing the problems encountered during the lesson integrated with technological tools, Student 3 gave a rating of 4 on a scale of 1–10 (1 being very easy, 10 being very difficult). However, Student 3 wrote, “I didn’t have any problems; everything was really good.” Additionally, Student 3 provided a rating of 5 on a scale of 1–10 (1 being not effective at all, 10 being extremely effective) regarding technology’s contribution to understanding of the lesson. In the elaboration, Student 3 recorded, “It was a little more interesting than our usual lesson.” The discrepancy was notable as, based on the elaboration, it was expected that the student

should have given a higher rating, considering no problems were encountered and the integrated technological tools enhanced their understanding of the lesson.

This discrepancy in the students' conflicting responses was realized by validity committee member 3. This validity committee member inquired why a student will assign 5 for a problem, when the said student also explained that he did not face any problem. This is what validity committee 5 said:

"In the questionnaire, some students gave 5 for difficulty, but why did they say 5? It means something was difficult, but we didn't know what that thing was. We didn't understand why they gave 5 because there was no other problem". (VCM No. 2).

On the same issue, Student 7 provided a rating of 6 on a scale of 1–10 (1 being not effective at all, 10 being extremely effective) and expressed, "I think technology helped us. It was informative and, at the same time, funny. I understand all." Yet still, Student 7 gave a rating of 6 on a scale of 1–10 (1 being not enjoyable at all, 10 being extremely enjoyable) for the enjoyment of the lesson with technology. Student 7 elaborated, "In my opinion, it was enjoyable. We have some games, such as Kahoot and Wordwall. It was funny." Despite these positive comments, the ratings given by Student 7 were not as high as expected. Considering these discrepancies, validity committee member 2, during the meeting, recommended that the researcher carefully review all students' responses on the questionnaire before proceeding with interviews. This is what validity committee member 2 said:

"You're having an interview? Take a quick look at the questionnaire before the interview, and take a quick look at the questionnaire during the interview. You can explain a little more to the children in the interview. You can get some more information if you look at the results of the questionnaire before the interview". (VCM No. 2).

The validity committee 2 member's suggestion would provide the researcher with the opportunity to delve deeper into the students' perspectives, allowing for more detailed responses and clarification on any inconsistencies in their feedback.

Prior to the lesson, the seating arrangement of the students was transitioned from the traditional rows to two collaborative groups, and this arrangement persisted throughout the entire lesson. Consequently, both the simulation tasks in the middle of the lesson and the assessment at the end were conducted in groups. During the assessment stage, the students collaborated on both Wordwall and Kahoot activities using their laptops. The issue of group assessment was deliberated during the validity committee

meeting, where concerns were raised about the challenges of assessing individual students when using this approach. This is what validity committee member 3 said:

“During the assessment phase, you separated them into groups. I wonder if these groups held discussions before responding, or how did they proceed? When it comes to groups, sometimes a very good student in the group might dominate the discussion, and the other students do not provide any answers. As a result, the students who are smart or very hardworking answer almost immediately, while the other students remain silent. This makes it difficult to assess them accurately.” (VCM No. 3).

The validity committee members suggested that individual assessment was necessary to accurately assess each student's understanding of the lesson. To address this, validity committee member 2 recommended using Kahoot for individual assessments, allowing students to participate individually using their mobile phones. The implementation of this strategy was proposed for subsequent lessons. This is what validity committee member 2 said:

“Why are you collaborating on the assessment? Because you said you use collaborative learning and social constructivism. But there is no constructivism here. This is teacher-centered education. Therefore, I recommend that you make an individual assessment here. Maybe you can do two separate things: an individual and a group assessment. Because we normally assess both individual performance and group performance in group work and cooperative learning, I think you can use Kahoot for individual assessment.” (VCM No. 2).

In the researcher's observation during the lesson, it was noted that, due to time constraints, not all planned activities within the 80-minute two-lesson periods were able to be completed. The observation field note highlighted that significant time was spent on tasks such as arranging seating, setting up students' laptops, and opening and logging into various technological tools. To address this issue, validity committee member 2 recommended that the researcher develop a technology integration timeline. This is what validity committee member 2 said:

“To address the time problem, review the entire lesson plan and calculate how many minutes each stage will take on average.” (VCM No. 2).

This timeline would outline the steps, activities, time allocations, and duration of the entire lesson, providing a structured guide to be followed. The committee members believed that the effective use of this technology integration timeline could address the problem and ensure more efficient time management in subsequent lessons.

Additionally, during the lesson, a problem of excessive technology integration was observed. This issue arose due to the use of numerous technological tools, including a

video, animation, two simulations, Wordwall, and Kahoot. It was believed that the integration of these multiple tools also contributed to time constraints. The validity committee members provided various recommendations to address this issue. According to validity committee member 2, our aim is to find an effective way of integrating technology into the lesson, not to integrate technological tools throughout the lesson. This is what validity committee member 2 said:

"We do not have to use technology at every stage of the lesson. We aim to integrate technology effectively, but it is not mandatory to use it at every stage of the course. I think you can use either Kahoot or Wordwall; you don't really need both." (VCM No. 2).

Validity committee member 3 also concurred with the view of validity committee member 2. According to validity member 3, It is not necessary to use too many animations and simulations. One or two simulations will suffice. This is what validity committee member 2 said:

"It is not necessary to include too many animations and simulations. Including one or two simulations would be enough." (VCM No. 2).

3.2. Findings from the Second Week of Implementation

The previous week's action decisions guided the second week's implementation process. The researcher reflected on all committee decisions, as shown in Table 13 of the lesson plan. The revisions for the second week's implementation process were as follows:

1. A more challenging simulation task was selected and integrated into the lesson to address the issue of techno-centric distractions.
2. Plans were made to review the students' questionnaires before conducting the semi-structured focus group interview to address the issue of students providing conflicting responses during the interview compared to their questionnaires.
3. ESL Games Plus was chosen for group assessment, while Kahoot was designated for individual assessment of the students after the lesson.
4. A technology integration timeline was developed to guide the lesson and address the issue of time constraints.

The data from the second implementation, collected from various stakeholders, is detailed in this section. The analysis encompasses data collected from the researcher, students, and validity committee members. The sources of data include the researcher's pre-implementation reflection journal, observation field notes, observation protocol,

students' reflection journal, questionnaire, focus group interview, researcher's post-implementation reflection journal, and records from the validity committee meetings. The findings derived from the data are presented in a chronological manner, addressing the beginning, middle, and end phases of the implementation.

Table 13. *Summary of the lesson plan, technological tools, and the data collection instruments utilized throughout the second implementation*

Course Title	Science
Class	7 th Grade
Unit	Unit 3: Forces and Energy
Topic	3.2: Speed
Time	80 Minutes
Date	27 th November, 2023
Course Book	Cambridge Lower Secondary Science Learner's Book 8
Learning Objectives	By the end of the lesson the students will be able to: • Understand what is meant by speed • Learn about the unit of speed • Be able to calculate speed
Technology Integration Tools	• Video • Animation • Simulation • Game (ESL Games Plus) • Kahoot
Data Collection Instruments Utilized Throughout the Implementation	1. Researcher's pre-implementation reflection journal 2. Observation field note 3. Observation protocol 4. Students' reflection journal 5. Questionnaire 6. Semi-structured focus group interview 7. Researcher's post implementation reflection journal 8. Validity committee meeting records

In Table 13, a summary of the lesson plan, learning objectives, technological tools, and data collection instruments utilized during the second implementation is presented. The lesson duration was 80 minutes, equivalent to two class periods. Furthermore, the lesson focused on the topic of speed, specifically under unit three of forces and energy from the Cambridge Lower Secondary Science Learner's Book 8. This implementation took place on November 27, 2023, with 7th-grade students. The learning objectives for this implementation were to enable students to understand the concept of speed, learn about the unit of speed, and be able to calculate speed. The technological tools integrated during the implementation encompassed video, animation, simulation, ESL Games Plus,

and Kahoot. Lastly, the data collected throughout this implementation included the researcher's pre-implementation reflection journal, observation field notes, observation protocol, students' reflection journals, questionnaire, semi-structured interview, researcher's post-implementation reflection journal, and validity committee meeting records.

3.2.1. Findings from the researcher's pre-implementation reflection journal

Prior to the lesson, the researcher recorded a reflection journal outlining the planned activities for the upcoming lesson. This reflective journal served as a blueprint, providing guidance for the researcher throughout the lesson. Within the reflection journal, the researcher elucidated the rationale behind the integration of various technological tools into the science lesson. Comprehensive details regarding the selected technological tools and their sources were outlined. Moreover, the reflection journal detailed the specific science topic on which the technological tools would be utilized. It also elucidated the hardware that would be used to support the other technological tools, especially software, during the lesson. Additionally, in the reflection journal, the researcher elaborated on the strategies that would be used to solicit information from students to assess their understanding of the lesson. Finally, the researcher elaborated on his confidence in ensuring that the lesson unfolds smoothly and his confidence in addressing any problems that will emerge. The topics covered in the reflection journal laid the groundwork for the identification of themes used in the descriptive analysis of the researcher's pre-implementation reflection journal. Seven distinct themes emerged from this analysis, providing valuable insights into the planning and anticipation of challenges in the integration of technological tools into the science lesson. The themes that emerged are presented below:

1. Purpose of Implementation
2. Technological Tools and Their Sources
3. Topics for Technology Integration
4. Technology Integration Process and Phases
5. Technological Hardware to Be Integrated
6. Soliciting Data About the Implementation
7. Confidence in Implementation

3.2.1.1. Purpose of implementation

Under this theme, the researcher provided detailed insights into the purpose of the upcoming science lesson, in which various technological tools would be integrated. According to the researcher, the objectives of this whole implementation are threefold. Firstly, the primary aim is to enhance the researcher's teaching practice within the domain of science education. Secondly, the researcher expressed a keen interest in investigating and experimenting with effective methodologies for seamlessly integrating technological tools into the science lesson. Finally, the researcher outlined the intention to assess how the integration of these technological tools would contribute to both the understanding and enjoyment of the science lesson for the students. This theme succinctly captures the multifaceted goals of the researcher for the impending lesson, emphasizing professional development, pedagogical exploration, and student engagement. This is what the researcher recorded in the pre-implementation reflection journal:

"I hope you are doing well today. I am writing to update you once again about my upcoming implementation, scheduled for Monday, November 27, 2023. The objective for this implementation remains unchanged: to enhance my teaching practices, explore effective methods of integrating technological tools into science lessons, and assess how these tools contribute to students' understanding and enjoyment of the science lesson." (Ankara, 26th November, 2023, Line Number: 1-5).

3.2.1.2. Technological tools and their sources

Under this theme, the researcher detailed the anticipated technological tools slated for integration into the science lesson and their respective sources. As per the researcher's pre-implementation reflection journal, the anticipated tools encompass video and animation content from YouTube ([http-3](#)), simulations from PhET ([http-2](#)), an interactive game sourced from ESL Games Plus ([http-4](#)), and Kahoot ([http-5](#)). Significantly, the researcher underscored the open-source nature of all these technological tools, guaranteeing broad accessibility without financial constraints. Notably, despite the availability of a paid version of Kahoot, the researcher intentionally chose the free version. This entry in the pre-implementation reflection journal captured the researcher's strategic decisions and commitment to leveraging open-source tools for enhanced accessibility and engagement. This is what the researcher recorded in the pre-implementation reflection journal:

“In the upcoming implementation, various technological tools will be integrated, including video, animation, simulation, and games such as Kahoot. The video and animation content are sourced from YouTube, the simulations from PhET, and the game from ESL Games Plus, alongside the use of Kahoot. It's important to note that all these technological tools are open-source and available for free use by everyone. While Kahoot does offer a paid version, I will be utilizing the free version and have personally created my own set of questions to be used on the platform.” (Ankara, 26th November, 2023, Line Number: 6-12).

3.2.1.3. Topics for technology integration

According to the researcher's pre-implementation reflection journal entry, the science topic chosen for the integration of various technological tools is speed. According to the researcher, the challenge that lies in the topic that calls for the integration of technological tools is the intricacies that lie in the calculations involving variables like speed, distance, and time. This theme encapsulates the researcher's strategic integration of technological tools, aimed at simplifying and navigating the complexities inherent in these calculations. The overarching objective is to empower students with effective tools that facilitate a more comprehensive understanding and application of the concept of speed. This is what the researcher recorded in the pre-implementation reflection journal about the science topic in which the technological tools would be integrated:

“The integration of technological tools in the upcoming lesson will centre around the topic of speed. This concept is fundamentally about the distance covered by an object within a specified time. While the concept itself is straightforward, the challenging aspect of the lesson lies in the calculations involving variables like speed, distance, and time.” (Ankara, 26th November, 2023, Line Number: 13-16).

3.2.1.4. Technology integration process and phases

This theme highlights the integration of various technological tools at different phases of the lesson, spanning the beginning, middle, and end. The researcher plans to integrate video and animation at the beginning to elucidate the fundamental concept of speed. In the middle phase, the students will collaboratively engage in a simulation task using PhET's "Moving Man." The lesson will conclude with an assessment phase, during which the researcher intends to employ games from ESL Game Plus and Kahoot to evaluate the students' comprehension. Importantly, the researcher aims to assess collaborative learning using the game from ESL Game Plus and individual understanding through Kahoot. The rationale behind this dual assessment strategy, as outlined by the

researcher, is to promote collaborative learning and peer scaffolding among the students. The researcher documented the following in the pre-implementation reflection journal:

“At the beginning of the lesson, a video and animation will be presented to elucidate the fundamental concept of speed. In the middle of the lesson, the students will collaboratively engage in a simulation task on their laptops using PhET's "Moving Man." This simulation will aim to provide hands-on experience for interpreting the position, time, distance, and velocity of the walking figure. A key focal point of this topic is the intricate relationship between speed, distance, and time. To delve deeper into this, the students will actively solve numerous questions using an online game and sum up the lesson with a Kahoot session. This strategy will aim to reinforce the understanding of the interplay between these variables through interactive and engaging activities.

At the assessment stage, thus, at the end of the lesson, the students will actively participate in collaborative assessments using the ESL Game Plus as a group. In contrast, Kahoot will be individually completed by the students using their smartphones. The rationale behind this dual assessment strategy is to promote peer-scaffolding among the students during the group activities, encouraging them to support and learn from each other. The individual completion of the Kahoot will serve as a direct measure to assess each student's independent understanding of the lesson, evaluating their ability to answer questions without reliance on peer or teacher scaffolding.” (Ankara, 26th November, 2023, Line Number: 16-32).

3.2.1.5. Technological hardware to be integrated

This theme details the hardware components essential for supporting the technological tools during the lesson. According to the researcher's pre-implementation reflection journal entry, the hardware will include two laptops, a smartboard, and smartphones. The smartboard will be used to display various tools, such as the Cambridge Lower Secondary Science Stage 8 software, video, animation, simulation, game, and Kahoot. The laptops will be utilized by the students for collaborative engagement during the simulation task and the game. Lastly, the students will employ their smartphones for individual completion of the assessment task on Kahoot. The researcher documented these details as follows:

“In the upcoming lesson, a variety of technological devices will be employed, including laptops, a smartboard, and smartphones. The smartboard will serve as the main display for various technological tools such as the Cambridge Lower Secondary Science Stage 8 software, video content, animation, simulation, a game, and Kahoot. The students will utilize the laptops to actively engage in the collaborative simulation task and the game. Additionally, the individual completion of the Kahoot task will be facilitated by using smartphones. This multi-device approach will aim to enhance interactivity, collaboration, and individual

participation, catering to the diverse aspects of the lesson's activities.” (Ankara, 26th November, 2023, Line Number: 33-40).

3.2.1.6. Soliciting data about the implementation

At the end of the lesson, the researcher intended to employ various methods, including a questionnaire, students' reflection journals, and semi-structured interviews, to gather data from the students regarding the implementation. According to the researcher, these data collection tools would yield detailed insights into the challenges the students will face during the lesson and how the integrated technological tools will contribute to their understanding and enjoyment of the lesson. Additionally, the interviews and student reflections will aim to provide information on the overall perceptions of the students regarding the integration of technology into science lessons. Finally, the researcher expressed the intention to document all occurrences during the lesson through observation field notes, capturing the intricacies of the lesson. Below is the information recorded by the researcher in that regard:

“Following the lesson, I plan to gather comprehensive feedback from the students using a structured three-question questionnaire featuring a rating scale. This will allow them to express insights on the challenges that will be encountered due to the integrated technological tools, as well as how these tools will contribute to both their understanding and enjoyment of the lesson. Additionally, an exit ticket in the form of a reflection journal will be employed, inviting the students to share their individual views and perceptions about the lesson. To gain further depth of understanding, I will conduct a focus group interview with the students. This interactive session will aim to solicit insights that will not be captured by the questionnaire and the reflection journal, providing a more nuanced perspective. Immediately after the implementation, I will diligently document my observations, capturing the intricacies of the lesson. This observation field note will serve as a valuable resource, enabling me to complete the observation protocol and reflect on the overall effectiveness of the implemented technological tools.” (Ankara, 26th November, 2023, Line Number: 41-53).

3.2.1.7. Confidence in implementation

This theme reflects the researcher's confidence derived from past implementation. According to the researcher, the experience he gained from the previous implementation has given him the confidence that he will be able to successfully integrate the various technological tools into the lesson and also address any challenges that will emerge. The researcher also tried to balance confidence with caution, which highlights the researcher's

commitment to meticulous attention to details and flawless execution as a top priority throughout the implementation. The researcher captured this as follows:

“Dear Diary, this time around, I find myself filled with confidence that everything will unfold according to plan. Drawing from the experiences of previous implementations, I believe I am well-prepared to handle any unforeseen events that may arise. While my confidence is high, I recognize the importance of proceeding with caution, taking things slowly, and paying meticulous attention to details. Ensuring each section of the implementation is executed flawlessly is my priority.” (Ankara, 26th November, 2023, Line Number: 54-59).

3.2.2. Findings from the researcher’s observation field note

The data from the observation field note underwent analysis, resulting in the emergence of seven themes and their respective sub-themes. Various patterns, recurring topics, and significant concepts derived from the observation field notes served as references in forming these themes and sub-themes. The themes and sub-themes that emerged from the observation field notes are presented in Table 14.

Table 14. Themes and sub-themes emerged from the researcher’s observation field note during the second implementation

Themes	Sub-themes
1. Lesson Preparation and Classroom Setup	Organization of Classroom Space Technological Tools Setup Students’ Population
2. Lesson Introduction and Engagement with the Content	Communication of Instructional Objectives Engagement through Multimedia Students’ Interaction and Understanding
3. Simulation and Hands-On Activities	Pre-Simulation Tasks Simulation Tasks Hands-On Activities
4. Lesson closure	
5. Assessment with Technological Tools	ESL Games Plus and Kahoot Scoring and Feedback
6. Problems Encountered and Their Solutions	Slow Cursor Movement Adaptations During the Lessons
7. Reflection	

3.2.2.1. Lesson preparation and classroom setup

Under this theme, the researcher emphasizes the physical arrangement of the classroom space before the lesson to accommodate and facilitate the integration of various technological tools into the science lesson. The researcher elaborates on how the classroom seating arrangement transitioned from traditional rows to cooperative groups,

creating an optimal learning environment for the students. The researcher details this process as follows:

“I entered the class at around 10:10 am to teach a science lesson on the topic of speed to 7th-grade students. Equipped with two laptops, the Cambridge Lower Secondary Science Stage 8 textbook, and printed questionnaire papers, I began by rearranging the classroom seating between 10:10 and 10:20 a.m. I organized the desks into two groups, one with four seats and the other with three seats.” (27th November, 2023, Observation Field Note, Line Number: 1-5).

The second sub-theme within this category focuses on the setup of technological tools before the science lesson. This involved the opening and logging into the smartboard and students' laptops, along with the preparation of the Cambridge Lower Secondary Science Stage 8 software, a video, an animation, a simulation from PhET, a game, and Kahoot. This procedure aimed to guarantee that all the devices and the software were prepared and operational for use during the lesson. The researcher documented this process as follows:

“Additionally, I set up the students' laptops in front of each group, opened and logged into the Cambridge Lower Secondary Science Stage 8 software, a video, an animation, a simulation from PhET, a game from ESL Game Plus, and Kahoot on the smartboard.” (27th November, 2023, Observation Field Note, Line Number: 5-7).

Finally, following the organization of the classroom spaces and the confirmation that all technological tools slated for integration into the lesson were operational and prepared, the researcher provided details on the students' population set to participate in the lesson. The researcher articulated this aspect as follows:

“The class population is eight; however, one male student was absent, resulting in the participation of only seven students—three males and four females—during the lesson.” (27th November, 2023, Observation Field Note, Line Number: 7-9).

3.2.2.2. Lesson introduction and engagement with the content

This theme delves into the technological tools utilized and their application in introducing the lesson to the students. Within this theme, three sub-themes have emerged. The first sub-theme centers on the researcher communicating the lesson's objectives to the students, establishing the framework for what they were expected to learn. At this stage, the researcher also engaged the students in a question-and-answer session to assess their relevant prior knowledge before presenting the main content of the lesson. This process was documented as follows:

“Following that, between 10:20 and 10:25 am, the lesson was presented on the smartboard. During this period, the instructional objectives of the lesson were communicated to the students, and a brief question-and-answer session was conducted to assess their relevant previous knowledge related to the lesson. Furthermore, I informed the students about the technological tools that would be integrated into the lesson and explained when each tool would be introduced and utilized.” (27th November, 2023, Observation Field Note, Line Number: 10-16).

The second sub-theme, engagement through multimedia, focused on the multimedia tools such as videos, animations, and Cambridge Lower Secondary Science Stage 8 software that were used to engage the students during the lesson. This was recorded by the researcher as follows:

“From 10:25 to 10:30 am, a brief video on the topic of speed, sourced from YouTube, was presented to the students using the smartboard. The students were quiet and engaged, attentively watching the video. The video effectively explained the relationship between speed, distance, and time.” (27th November, 2023, Observation Field Note, Line Number: 17-20).

The third sub-theme, "Students' Interaction and Understanding," delves into the interaction between the researcher and the students during the lesson, utilizing various technological tools. This sub-theme encompasses the researcher facilitating a discussion on the topic of speed, exploring the relevant formulas, and collaboratively solving questions. The recorded details are as follows:

“Following the video presentation, around 10:30 am, the lesson in the Cambridge Lower Secondary Science Stage 8 software was displayed on the smartboard and discussed with the students. During this segment, the concept of speed was deliberated upon. We delved into the definition of speed and explored the formula for calculating it. Additionally, we deduced the formulas for calculating distance and time based on the formula for calculating speed. Subsequently, we worked through two examples from the Cambridge Lower Secondary Science Stage 8 software on the smartboard.” (27th November, 2023, Observation Field Note, Line Number: 22-28).

Furthermore, the interaction between the researcher and the students during the lesson encompassed the observation of the students' responses after utilizing various technological tools. According to the researcher's observation journal, the students demonstrated a clear understanding of the lesson based on their demeanour throughout the session. The researcher captured this observation as follows:

“Judging by the students' facial expressions, it appeared that they not only enjoyed the content but also understood it, as indicated by their nods of agreement throughout the video.” (27th November, 2023, Observation Field Note, Line Number: 20-21).

3.2.2.3. Simulation and hands-on activities

This theme focuses on the simulation and hands-on activities conducted by the students during the lesson. Within this theme, three sub-themes have emerged. The first sub-theme, "Pre-Simulation Task," elucidates the preparatory activities that the students underwent before engaging in the simulation tasks. According to the observation field note, these activities involved displaying an animation on the smartboard for the students. The animation served as a demonstration of how the simulation task would be executed. The researcher recorded this as follows:

"An animation on speed was displayed to the students on the smartboard. The discussion and question-and-answer session, along with the feedback received from the students, provided me with complete assurance that the students had a solid grasp of the lesson. I chose to display the animation to reinforce their understanding of the concept and to infuse an element of enjoyment into the lesson. From my observations of the students' facial expressions and demeanour, it was evident that the animation not only enhanced their understanding of the topic but also made the lesson more enjoyable for them." (27th November, 2023, Observation Field Note, Line Number: 29-35).

Following the students' completion of watching the animation demonstrating how to carry out the simulation task, the researcher proceeded to guide them through a step-by-step demonstration, providing clear explanations regarding the upcoming simulation. Moreover, the researcher expounded on the objective of the upcoming simulation, emphasizing that its successful completion would serve as an indicator of the students' understanding of the task. The researcher elaborated on this process as follows:

"Around 10:45 am, I provided the students with a detailed explanation and step-by-step instructions for a simulation task called "Moving Man," sourced from PhET. Their objective was to position the "Moving Man" at a specific location, guide him through a defined distance within a particular time frame, and calculate the resulting speed. The simulation proved highly beneficial, aiding the students in differentiating between speed and velocity." (27th November, 2023, Observation Field Note, Line Number: 36-40).

The final sub-theme within this category underscores the collaborative manner in which the students effectively carried out the simulation task. According to the researcher's observation field note entry, the students enthusiastically and successfully completed the simulation task, showcasing a clear understanding of the topic. The researcher elaborated on this as follows:

"Engaged and collaborative, the students completed the task with enthusiasm, demonstrating a clear understanding of the lesson. Following this activity, the students took a break." (27th November, 2023, Observation Field Note, Line Number: 40-42).

3.2.2.4. Lesson closure

The completion of the simulation task by the students marked the conclusion of the lesson. Subsequently, the researcher summarized the entire lesson. Additionally, the researcher addressed any questions posed by the students about the lesson. The researcher captured this concluding phase as follows:

“I summed up the lesson with a summary of the key points and addressed any questions or concerns the students had. Once I ensured that all queries were addressed, we seamlessly transitioned to the assessment stage of the lesson.” (27th November, 2023, Observation Field Note, Line Number: 46-49).

The lesson closure signalled the conclusion of the lesson. This phase marked the initiation of the assessment stage, where the researcher evaluated the students' understanding of the science lesson integrated with various technological tools.

3.2.2.5. Assessment with technological tools

This theme underscores the technological tools employed to assess the students' understanding of the science lesson. The first sub-theme highlights the technological tools utilized during this phase, including ESL Game Plus and Kahoot. Furthermore, the second sub-theme expounds on the students' performance during the assessment phase using these technological tools. Notably, the students collaborated on completing the ESL Game Plus, for which they demonstrated excellent performance. The researcher elaborated on this as follows:

“For the assessment stage, I utilized ESL Games Plus and Kahoot as the technological tools. The students began with collaborative participation in the ESL Games Plus, where they answered questions displayed on the smartboard alternately between the groups. The ESL Games Plus consisted of ten questions exclusively focused on calculating speed, distance, and time. Impressively, both groups excelled, achieving perfect scores of 5/5. What particularly caught my attention was the remarkable collaboration and teamwork displayed by the students. It was a marvellous experience, and this assurance further solidified my belief that the integrated technological tools significantly enhanced the students' understanding of the lesson.” (27th November, 2023, Observation Field Note, Line Number: 50-58).

After the collaborative completion of the ESL Game Plus, the students proceeded to individually and collaboratively undertake the assessment using Kahoot. Although the initial plan was for the Kahoot assessment to be completed individually by the students with their smartphones, because some of them did not have their phones, they were paired

with their peers. Consequently, the Kahoot assessment was completed both individually and collaboratively by the students. In terms of performance, the students demonstrated excellence on Kahoot as well. The researcher elaborated on this as follows:

“Following the ESL Games Plus, the students proceeded to carry out tasks on Kahoot, which also comprised 10 questions encompassing all aspects of the lesson. Each student completed the Kahoot task individually on their smartphones. However, two students did not have smartphones, so they were paired with two other students who had smartphones and worked collaboratively to complete the task. In the end, three students completed the task individually, and two groups, each consisting of two students, completed the task collaboratively. The students performed exceptionally well, as indicated by the feedback from Kahoot. At the end of the Kahoot task, a collaborative group emerged in first place, followed by an individual, and then another collaborative group.” (27th November, 2023, Observation Field Note, Line Number: 59-67).

3.2.2.6. Problems encountered and their solutions

Under this theme, the researcher elaborated on the problems encountered during the implementation and how they were resolved. The problem highlighted under this theme was encountered by some students. According to the students, they found the mouse or cursor on the laptop they were using during the lesson to be moving very slowly to their liking. However, they did not report this issue to the teacher and managed to use the mouse/cursor as it was. The researcher succinctly captured this encounter as follows:

“In this implementation, everything unfolded as planned, and no major challenges were encountered. Two students stated in their questionnaire entry that they had encountered a challenge with the laptop cursor: I inquired if they had reported the issue and whether it had been resolved.” (27th November, 2023, Observation Field Note, Line Number: 76-79).

During the break, the researcher implemented some strategic adaptations. The researcher executed plans to retrieve students' mobile phones intended for the upcoming Kahoot assessment. Additionally, the researcher ensured that all opened simulation windows on the students' laptops remained active and running, aiming to conserve valuable lesson time that would otherwise be spent logging in and reopening them. The researcher documented these actions in the observation field note as follows:

“During the ten-minute break, I took the opportunity to retrieve the students' phones from the office for use in the upcoming Kahoot activity. Additionally, I double-checked and ensured that all the open windows on the students' laptops were still active and running.” (27th November, 2023, Observation Field Note, Line Number: 43-45).

In the research setting, students were allowed to bring phones to school, but their phones were taken and kept in the vice principal's room until closing time. However, there are certain situations where students are permitted to use their phones. One of such situations is when students need their phones for education-related activities. In this study, for example, their phones were retrieved from the vice principal's office for the Kahoot activity.

3.2.2.7. Reflection

After the lesson, the researcher solicited data from the students to evaluate the entire implementation, focusing not only on their understanding of the lesson but also on their overall experience. In this process, the researcher conducted a post-lesson reflection using a questionnaire. During this reflection, the students provided insights into the problems they encountered and the contribution of technology to their understanding and enjoyment of the lesson. Additionally, an exit ticket in the form of a reflection journal was employed, where the students expressed their reflections on the entire science lesson integrated with various technological tools. The researcher documented this phase of the implementation as follows:

"After the completion of the assessment activities, I informed the students that they would be required to fill out a brief questionnaire reflecting on their experience with the technology-integrated science lesson. The questionnaire delved into their encounters with any challenges during the technology-integrated lesson, how the technological tools contributed to their understanding, and their overall enjoyment of the lesson due to the integrated technology. The questionnaire included a rating scale from 1 to 10 for them to express their experiences. Once I explained the questionnaire and its components, I rearranged their seating from groups into their previous traditional seating rows. The students then individually completed the questionnaire. Additionally, I asked them to write an exit ticket—a brief reflection on the lesson." (27th November, 2023, Observation Field Note, Line Number: 80-88).

3.2.3. Findings from the researcher's observation protocol

During the lesson, the researcher, guided by an observation protocol, made observations regarding the interactions among the students and the technological tools integrated into the lesson. The observation protocol comprised a structured framework that the researcher utilized to systematically record and document the students' behavior during the session. Table 15 illustrates the themes and subthemes that emerged from the researcher's observation protocol during the second implementation.

Table 15. Themes and sub-themes emerged from the researcher's observation protocol during the second implementation

Themes	Sub-themes
1. Integration of Technological Tools	Technological Tools Utilized Technological Tools Integration Phases
2. Utilization of Technological Tools in Lesson Activities	Initial Activities Mid-Lesson Activities Concluding Activities
3. Students' Participation and Interaction with Technological Tools	Beginning-of-Lesson Response Mid-Lesson Interaction End-of-Lesson Engagement Active Participation
4. Problems Encountered by Students	Slow Cursor Movement
5. Resolution of Encountered Problems	Mouse Functionality Adjustment
6. Impact of Technological Tools on the Classroom Environment	Seating Arrangement Change Enhanced Interaction and Support

3.2.3.1. Integration of technological tools

During the science lesson, the researcher seamlessly incorporated diverse technological tools obtained from various sources. The selection and integration of these tools were executed with strategic intent, aiming to enrich different facets of the lesson and accommodate the diverse learning styles of the students. The researcher meticulously outlined the technological tools integrated into the lesson within the observation protocol as follows:

"The lesson incorporated various technological tools, including a video, an animation, a simulation, an ESL Game Plus, and Kahoot." (Observation Number 2, Date: 27th November, 2023).

The second sub-theme highlights the specific stages at which the technological tools were seamlessly integrated into the lesson. The researcher adeptly employed and integrated these tools at various phases, stemming from the beginning of the lesson, advancing through the middle phase, and culminating at the end of the lesson. The observation protocol contains detailed insights into these stages, as elucidated by the researcher as follows:

"A video and animation were presented at the beginning of the lesson. In the middle of the session, the students engaged in a simulation task. Finally, for assessment purposes, ESL Games Plus and Kahoot were employed at the end of the lesson." (Observation Number 2, Date: 27th November, 2023).

3.2.3.2. Utilization of technological tools in lesson activities

Within this theme, the researcher delved into comprehensive details regarding the learning activities facilitated by the technological tools. The integrated technological tools were utilized across distinct phases of the lesson, encompassing the beginning, middle, and end. Consequently, three sub-themes surfaced, elucidating the initial activities, mid-lesson activities, and concluding activities.

At the beginning of the lesson, the researcher displayed the Cambridge Lower Secondary Science Stage 8 on the smartboard. To engage the students, a question-and-answer session was conducted to assess their relevant prior knowledge of the science topic. Following this, a video was strategically employed to deliver a succinct and vivid introduction of the science topic under discussion. Additionally, an animation was seamlessly integrated at this stage to further elucidate and establish the foundation of the topic. Introducing these technological tools at this point in the lesson served a dual purpose of providing a clear overview and laying the groundwork for the learning objectives. The researcher detailed these actions in the observation protocol as follows:

“At the beginning of the lesson, a question-answer session was conducted using the Cambridge Lower Secondary Science Stage 8 software displayed on the smartboard. Subsequently, the students watched a video and animation presented on the smartboard, followed by engaging in a classroom discussion.” (Observation Number 2, Date: 27th November, 2023).

Midway through the lesson, the researcher seamlessly integrated a simulation. The students collaborated to complete the simulation task, calculating variables like speed, distance, and time. The researcher provided additional details on this integration in the observation protocol as follows:

“In the middle of the lesson, the students participated in a simulation task, calculating speed, distance, and time.” (Observation Number 2, Date: 27th November, 2023).

Finally, at the end of the lesson, thus the assessment phase, the researcher utilized various technological tools to assess the students’ understanding of the lesson. The technological tools utilized by the researcher at this stage of the lesson included ESL Games Plus and Kahoot. The students worked collaboratively with each other to complete the assessment tasks. The researcher elaborated on this in the observation protocol as follows:

“Towards the end of the session, the students collaboratively played ESL Games Plus, involving calculations related to speed, distance, and time. Additionally, the students

individually used Kahoot to answer questions that covered all aspects of the lesson.”
(Observation Number 2, Date: 27th November, 2023).

The Kahoot activity was planned to assess the individual understanding of the students. However, not all students brought their phones to school on the day of the implementation. As a result, some students completed the Kahoot individually, while those without phones were paired up to participate in the activity.

3.2.3.3. Students' participation and interaction with technological tools

The seamless integration of various technological tools occurred throughout the lesson, resulting in diverse interactions and reactions from the students. Notably, these interactions were not consistent across the entire session, with variations observed at the beginning, middle, and end of the lesson. The nuanced responses at different stages led to the identification of sub-themes highlighting the beginning-of-lesson response to the technological tools, mid-lesson interactions, and end-of-lesson engagement of the students with the technological tools.

At the beginning of the lesson, as the video and animation were displayed before the students, their responses indicated a pronounced comprehension and concordance with the content being presented.

“The students have conveyed a strong sense of understanding and agreement with the video and animation they watched at the beginning of the lesson.” (Observation Number 2, Date: 27th November, 2023).

In the middle of the lesson, the students exhibited predominantly positive responses toward the simulation task. Their reactions conveyed a sense of achievement and understanding, evident in their successful completion of the simulation task. The students not only showcased comprehension but also found the task enjoyable. The researcher recorded these observations in the observation protocol, highlighting the affirmative nature of the students' responses to the simulation task they carried out.

“In the middle of the lesson, the students collaboratively carried out the simulation task on their laptops. They expressed a great sense of accomplishment and highlighted that the task not only enhanced their understanding of the lesson but was also enjoyable.” (Observation Number 2, Date: 27th November, 2023).

Towards the end of the lesson, the students actively engaged in assessment activities aimed at evaluating their comprehension of the lesson content. At this phase, the ESL Game Plus and Kahoot were employed as assessment tools. The students participated

collaboratively in the ESL Game Plus, demonstrating cooperative problem-solving skills. For the Kahoot assessment, the students individually completed the task on their smartphones, with some collaborating in pairs due to the absence of smartphones for a few students. Notably, the students exhibited enthusiasm, expressed enjoyment, and even expressed a desire to play more Kahoot. The researcher outlined these details in the observation protocol as follows:

“Towards the end of the lesson, the students collectively answered the ESL Game Plus questions, presenting their answers on the smartboard, group by group. In the Kahoot session, the students answered questions individually on their smartphones, while those without smartphones were paired with their colleagues who had smartphones. The students really enjoyed the task and expressed a desire to engage in more Kahoot activities.”
(Observation Number 2, Date: 27th November, 2023).

The integration of various technological tools into the lesson consistently elicited active participation from the students. Their participation and engagement remained high from the beginning to the end of the lesson. The students demonstrated full attention and active involvement during the presentation of the video and animation at the beginning of the lesson, the collaborative execution of the assessment task, and the discussions held throughout the session. The researcher linked the students' comprehensive understanding of the lesson to their attentive and active participation during the entire class. The researcher provided further elaboration on this aspect as follows:

“The students were highly engaged and actively participated throughout the lesson. They dedicated their full attention and contributed effectively to both the video and animation segments, as well as the subsequent class discussion. The simulation task and the ESL Game Plus were completed collaboratively, while the Kahoot activity was carried out individually by the students. Additionally, the students consistently directed their attention toward the lesson content and the tasks being displayed and discussed. I would attribute their high level of attention and active participation as significant contributors to their understanding of the lesson.” (Observation Number 2, Date: 27th November, 2023).

3.2.3.4. Problems encountered by students

This theme focuses on the challenges encountered by students during the lesson. During the lesson, no problems were observed by the researcher or reported by the students. However, after the lesson, two students from the same group, sharing a laptop, expressed concerns about the cursor's speed, stating that it did not meet their preferences. The researcher documented this occurrence in the observation field note, as follows:

“Following the lesson, two students, Student 4 and Student 6, reported encountering computer-related issues. Student 4 mentioned that the mouse cursor wasn't moving as swiftly as he preferred. Student 6, on the other hand, stated that he had experienced a minor problem with the computer mouse as well.” (Observation Number 2, Date: 27th November, 2023).

3.2.3.5. Resolution of encountered problems

This theme delves into the concerns raised by the students regarding the cursor's slower movement. Upon investigation, it was determined that the students' concerns pertained to the speed of the cursor rather than a malfunction of the mouse. Student 6 expressed that the mouse was not as fast as he preferred, while student 4 acknowledged that the slow cursor movement was not a significant issue and that he handled it during the lesson. In light of these concerns, the researcher expressed the intention to adjust the cursor speed before the students' subsequent lesson, as documented in the observation field note.

“Upon investigating the issues reported by the students, it was discovered that the first problem was not related to a laptop malfunction as initially anticipated. Instead, it was a matter of preference regarding the mouse cursor movement speed. This feedback will be taken into consideration, and the necessary settings will be adjusted before the next implementation. As for the second problem, the student mentioned that it was not a significant issue; it was also about the cursor, and he was able to resolve it on his own.” (Observation Number 2, Date: 27th November, 2023).

3.2.3.6. Impact of technological tools on the classroom environment

To facilitate the seamless integration of technological tools into the science lesson, several adjustments were made in the classroom setting. These adjustments informed the development of two sub-themes: "Seating Arrangement Change" and "Enhanced Interaction and Support." The primary adjustment involved transitioning from traditional rows to group seating, aiming to foster a collaborative learning environment. This adjustment not only facilitated interactive lessons but also contributed to improved classroom management. The researcher elaborated on this adjustment in the observation field note, emphasizing its role in creating an environment conducive to collaborative learning and enhancing the overall learning experience for the students.

“In response to the integration of technological tools into the lesson, the seating arrangement of the students was transitioned from rows to groups. This change facilitated collaborative learning, enabling the students to actively participate in the lessons and complete tasks using

technological tools collaboratively. This adjustment not only fostered a more interactive classroom environment but also streamlined classroom management. By directing attention and tasks toward group activities rather than individual tasks, it became more efficient to supervise and guide the students.” (Observation Number 2, Date: 27th November, 2023).

Furthermore, the classroom adjustments made a positive impact on the dynamics among the students during the instructional process. The shift from traditional to group seating not only facilitated collaborative learning but also specifically enhanced interactions during the simulation activities and assessments. This change promoted peer support, fostering a collaborative environment where the students actively engaged with each other, solved problems collaboratively, and successfully completed tasks within the group setting. The researcher emphasized this positive impact, highlighting the benefits of increased peer interaction and support as a result of the adjusted seating arrangement.

“Moreover, the collaborative nature of the classroom, enhanced by the use of integrated technological tools, empowered the students to offer peer support. This was particularly evident during the simulation tasks and assessments on platforms like the ESL Game Plus, where the students engaged in peer scaffolding, assisting each other in problem-solving and task completion. The structured classroom order and the utilization of technological tools, such as Kahoot, made it feasible to assess the individual students’ understanding of the lesson.” (Observation Number 2, Date: 27th November, 2023).

3.2.4. Findings from the students’ exit tickets

Following the science lesson integrated with technological tools, the students were encouraged to share their experiences through exit tickets. It is also important to note that on this day, all the students were present except Student 8. Additionally, only Students 1, 2, 3, 4, 6, and 7 opted to write the reflection journal. However, despite Student 5 being present during the lesson, he opted not to write the reflection journal. The reflections written by the students at the end of the lesson are presented below.

Student 1 emphasized the beneficial role of various technological tools in learning the science topic of speed. According to her, the integrated technological tools significantly enhanced her understanding of the topic, making the learning process more efficient and enjoyable. Additionally, she mentioned that the collaborative nature of the lesson contributed to an enjoyable learning experience for her and she did not encounter any problems. The exit ticket of Student 1 is as follows:

“In today’s lesson, we used technological tools and devices to learn about speed. Using technology helped me understand things much easier and faster. I was able to see the

experiments and how they were done by the simulation. Additionally, I did it with my friends, which made it more enjoyable. We also didn't face any problems, and in my opinion, we should use technological tools more often.” (Second Week's Exit Ticket of Student 1).

Student 2 began her exit ticket entry by expressing how the integrated technological tools transformed the science lesson on speed into a fun and enjoyable experience. She emphasized the collaborative grouping during the viewing of the video and animation, noting that these tools were instrumental in expanding their understanding of speed calculations. Student 2 further detailed her experience with the simulation task, noting how it made the concept feel real and tangible. The games, specifically ESL Game Plus and Kahoot, used during the assessment stage were highlighted by Student 2 as enjoyable and effective in enhancing her speed calculation skills. Expressing a desire for more frequent inclusion of such games in science lessons, Student 2 provided valuable insights into the positive impact of technological tools on her learning experience. The exit ticket of Student 2 is as follows:

“Today was a very fun day, especially in science. We learned speed in the lesson, and our teacher grouped us together so we could watch a video about the lesson. We also watched an animation to expand our knowledge about the speed calculations, and after that, we played a simulation to experience what it would be like to do it. Then we played some games to help us calculate faster and answer faster in general. The games were very enjoyable too, and I would love to do them more.” (Second Week's Exit Ticket of Student 2).

Student 3 reflected on the science lesson as being highly enjoyable, attributing this positive experience to the incorporation of various technological tools. She specifically mentioned the video, animation, simulation, games, and Kahoot as the tools that enriched the lesson. Student 3 emphasized the collaborative learning environment, expressing satisfaction with understanding the topic alongside her friends. The exit ticket concluded with Student 3 expressing genuine enjoyment of the lesson. Here is the exit ticket of Student 3.

“Today's lesson was very nice. We used different technological tools, for example, videos, animations, simulations, games, and Kahoot. I understand the topic better with my friends. I liked working in groups. I really enjoyed today's lesson.” (Second Week's Exit Ticket of Student 3).

Student 4 also began his reflection by expressing how the technological tools integrated into the science lesson made the whole learning experience enjoyable for him. His exit ticket particularly highlighted the significance of the collaborative simulation task, underscoring its role in enhancing his understanding of the lesson. Student 4

concluded by recommending the regular use of technological tools in science lessons, considering it a fun and effective learning approach. Here is the exit ticket of Student 4.

"Today's lesson was enjoyable for me. We did simulations that helped me understand the topic. It was fun to do, and in my opinion, we should do more of them. It is a fun way to learn." (Second Week's Exit Ticket of Student 4).

In his exit ticket, Student 6 elaborated on how the integrated technological tools made the science lesson fun and also helped him stay focused during the lesson. Student 6 attributed these positive learning experiences specifically to the video, animation, simulation, ESL game, and Kahoot. Student 6 strongly advocated for the continued use of technological tools in science lessons. Student 6's exit ticket is presented below.

"The technologies helped me focus more on our lessons in a fun way. The videos helped, and the animation also helped. But mostly Kahoot and the simulation. The ESL games are also pretty good. The technology should stay in class." (Second Week's Exit Ticket of Student 6).

Student 7 in her exit ticket gave a succinct account of the topic they treated in class and went ahead to elaborate on the formula they used during their calculations of speed. Student 7 characterized the whole lesson as easy and enjoyable. This sentiment can be inferred as the result of the integration of the various technological tools into the lesson. Finally, Student 7 gave a short account of the activities they carried out throughout the lesson, starting from the beginning, middle, and end of the lesson. This is what Student 7 wrote in her exit ticket:

"In the lesson, I learned how to calculate speed, distance, and time. So, for speed, we need to divide distance by time. The lesson was easy and enjoyable. In the beginning, we studied after we watched the video; after that, we did some simulations; and finally, we played some games such as Kahoot." (Second Week's Exit Ticket of Student 7).

3.2.5. Findings from the questionnaire

After the science lesson integrated with various technological tools, the researcher employed a questionnaire to solicit information from the students about their learning experience. The sections of the questionnaire served as a reference for the development of themes. The themes that emerged from the questionnaire are as follows:

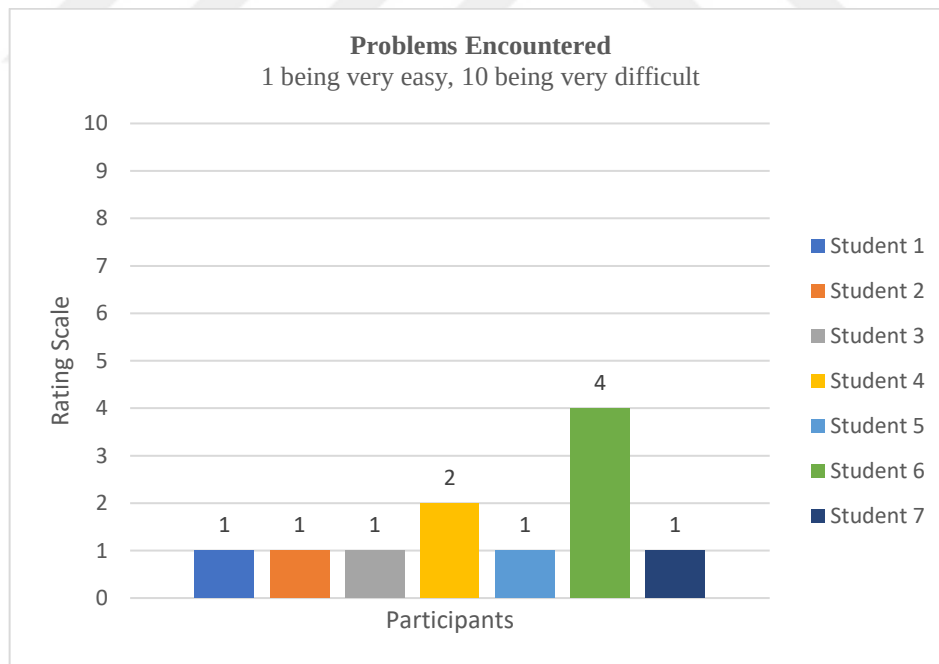
1. Problems Encountered
2. Technology's Contribution to Understanding
3. Enjoyment of the Lesson with Technology

3.2.5.1. Problems encountered

Under this theme, the problems encountered by students during the science lesson integrated with technological tools were elaborated. Table 16 presents the rating scale for the problems encountered by students during the second implementation.

Table 16. Rating scale on the problems encountered by the students during the second implementation

Participants	Rating Scale									
	1	2	3	4	5	6	7	8	9	10
Student 1	✓									
Student 2	✓									
Student 3	✓									
Student 4		✓								
Student 5	✓									
Student 6				✓						
Student 7	✓									



Graph 4. Difficulties encountered by students during the second implementation

Table 16 and Graph 4 illustrate that only seven students were present on the day of the implementation and subsequently completed the questionnaire after the lesson.

Student 8 was absent from school on the day of the implementation. The data from both the table and the graph revealed diverse ratings from the students regarding the problems they encountered during the lesson. A majority of the students, specifically five out of the seven, indicated that they did not encounter any problems or challenges during the lesson and rated 1 on the questionnaire. These students were Students 1, 2, 3, 5, and 7. Students 4 and 6 rated the problems they encountered during lessons 2 and 4, respectively. The specific reasons behind these ratings were provided in the second section of the questionnaire, which contained open-ended questions. Below are the responses provided by the students.

When the students were asked to elaborate about the difficulties, they had faced during the science lesson integrated with various technological tools, they responded with a concise statement. They expressed that they did not encounter any problems throughout the lesson. Unfortunately, the response did not provide specific details about their experience or any potential obstacles they might have faced. However, the absence of the challenges mentioned implies a smooth and problem-free experience for the students during the lesson. These positive responses suggest that the integrated technological tools were effectively utilized, contributing to a seamless learning experience for these students. Student 1, 2, 3, 5, and 7's comments are elaborated below:

Student 1: *"I didn't have any problems." (Answer of Student 1 for the First Question of the Second Week's Questionnaire).*

Student 2: *"I didn't have any problems." (Answer of Student 2 for the First Question of the Second Week's Questionnaire).*

Student 3: *"I didn't have any problems." (Answer of Student 3 for the First Question of the Second Week's Questionnaire).*

Student 5: *"I didn't have any problems with technology." (Answer of Student 5 for the First Question of the Second Week's Questionnaire).*

Student 7: *"I didn't have problems during the lesson." (Answer of Student 7 for the First Question of the Second Week's Questionnaire).*

Out of the seven students who participated in the lesson, Student 4 was one of two students who mentioned facing a problem with the computer during the lesson. Moreover, Student 4 clarified that the issue was not significant and that he managed to resolve it in the class without encountering any difficulties. Unfortunately, the questionnaire response lacked specific details regarding the nature of the problem and the steps taken to address it. Here is what Student 4 recorded in the questionnaire regarding the problems he encountered during the lesson:

"There was a little problem with the computer, but I figured it out without any difficulties."
(Answer of Student 4 for the First Question of the Second Week's Questionnaire).

Student 6, in his response, pointed out a specific issue with the mousepad on the laptop, expressing difficulty in its use during the lesson. While he did not provide extensive details about the problem in the questionnaire, he later communicated with the teacher, elaborating that the mousepad issue caused the cursor to move at a slower pace when using it during the lesson. This additional information was shared after the formal questionnaire. This is what Student 6 recorded in the questionnaire:

"The mousepad is a little hard to use on the laptop." *(Answer of Student 6 for the First Question of the Second Week's Questionnaire).*

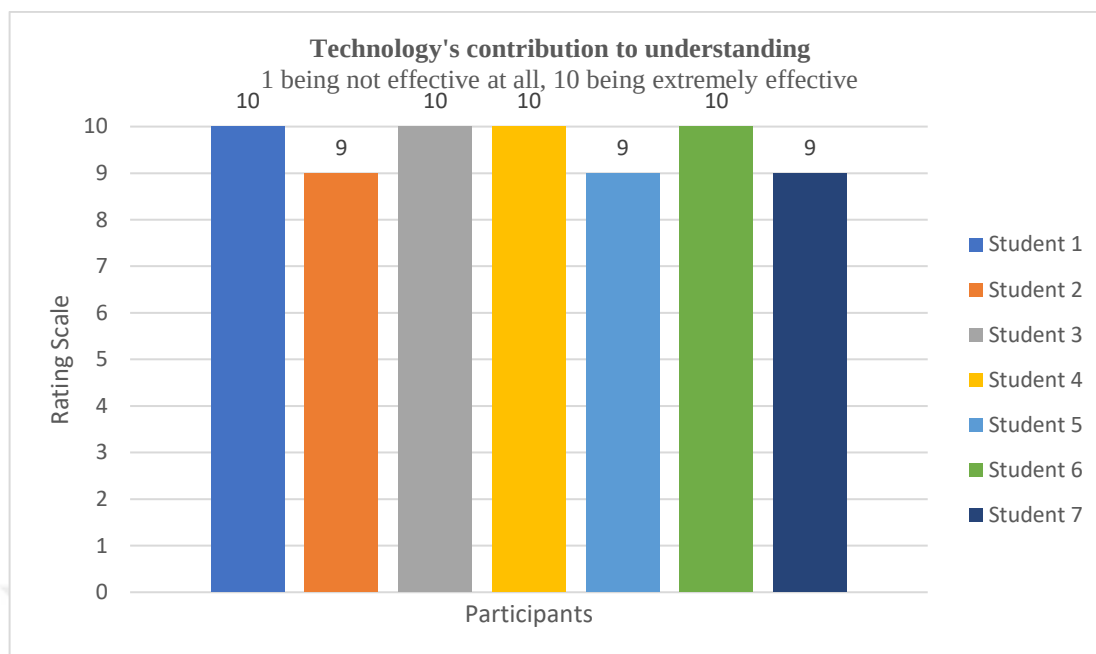
With the exception of Students 4 and 6, all others unequivocally conveyed that they did not encounter any problems during the science lesson integrated with technological tools. The majority of the students succinctly expressed that they did not face any challenges throughout the lesson. The only elaborated problem by the two students was difficulty using the mousepad and an issue with the computer. In a nutshell, excluding these isolated incidents, the technological tools posed no challenges or problems for the majority of the students. The consensus among the students was that the tools were easy to use and did not pose any problems.

3.2.5.2. Technology's contribution to understanding

This theme elucidates the contributions made by the integrated technological tools to the students' understanding of the science lesson. Table 17 displays the rating scale, illustrating technology's contribution to the students' understanding.

Table 17. *Rating scale on technology's contribution to understanding during the second implementation*

Participants	Rating Scale									
	1	2	3	4	5	6	7	8	9	10
Student 1										✓
Student 2									✓	
Student 3										✓
Student 4										✓
Student 5									✓	
Student 6										✓
Student 7									✓	



Graph 5. *Technology's Contribution to Understanding*

From Table 17 and Graph 5, it is evident that the majority of the students, specifically Students 1, 3, 4, and 6, provided a perfect rating of 10/10, expressing that the technological tools integrated into the science lesson significantly contributed to their understanding of the science lesson. Students 2, 5, and 7 also acknowledged the high contribution of the integrated technological tools to their understanding of the lesson and gave it a rating of 9. Notably, none of the students rated below 9, implying that, indeed, the integrated technological tools have significantly contributed to their understanding of the science concepts taught.

Moving on to the second section of the questionnaire, the students provided insightful comments, highlighting the positive impact of technological tools on their learning experience. The students' comments are presented below:

Student 1 expressed that the simulation task conducted during the lesson made it easier for her to visualize how the experiments were carried out. Student 1's comment is shown below:

"I could easily see how the experiments were done by the simulations." (Answer of Student 1 for the Second Question of the Second Week's Questionnaire).

In her comment, Student 2 specifically attributed the simulation task they completed during the lesson to contributing to her understanding of the topic taught. She highlighted its capability to provide real-life experiences for students. Student 2 further

elaborated on the overall impact of technology in enhancing students' comprehension of scientific concepts, characterizing it as a tool that helps them gain a deeper understanding. The following is Student 2's comment from the questionnaire:

"It can help us understand as if we are experiencing the simulation. I think technology can help us understand even more." (Answer of Student 2 for the Second Question of the Second Week's Questionnaire).

Student 3 attributed the use of technological tools and the collaborative task during the assessment stage as more engaging and enjoyable, which ultimately enhanced her understanding of the entire lesson. Here is what Student 3 wrote in the questionnaire:

"It was better and more fun when we used a computer and phone for Kahoot. I understood everything." (Answer of Student 3 for the Second Question of the Second Week's Questionnaire).

Student 4 explicitly expressed the positive impact of the integrated technological tools on his understanding of the science lesson. He initially characterized these tools as nice, emphasizing their pivotal role in fostering his understanding and facilitating the learning process. Moreover, he highlighted the enjoyable aspect of the lesson. This is what Student 4 wrote in the questionnaire:

"It was nice. It made me understand and made me learn, and I also had lots of fun in the lesson." (Answer of Student 4 for the Second Question of the Second Week's Questionnaire).

Student 5, in his comment regarding how the integrated technological tools influenced his understanding of the science lesson, did not explicitly outline the specific ways in which these tools contributed to his understanding. However, he stated that they facilitated his learning throughout the lesson. This is what Student 5 recorded in the questionnaire:

"It's helping to learn the unit." (Answer of Student 5 for the Second Question of the Second Week's Questionnaire).

Student 6 characterized the integrated technological tools in the science lesson as beneficial, describing them as "good." He explicitly acknowledged that these tools played a role in enhancing his understanding of the lesson. Additionally, Student 6 emphasized how the technological tools contributed to making the lesson more fun.

"Good, it helps me understand the lesson more in a fun way." (Answer of Student 6 for the Second Question of the Second Week's Questionnaire).

Student 7 explicitly conveyed a strong understanding of the lesson, attributing her understanding to the integrated technological tools. She specifically mentioned that these

tools facilitated her understanding of calculating speed, distance, and time. This is what she recorded in her questionnaire:

“I understand well with technology. It helped me to understand how to calculate speed. And how to calculate distance and time during simulation.” (Answer of Student 7 for the Second Question of the Second Week’s Questionnaire).

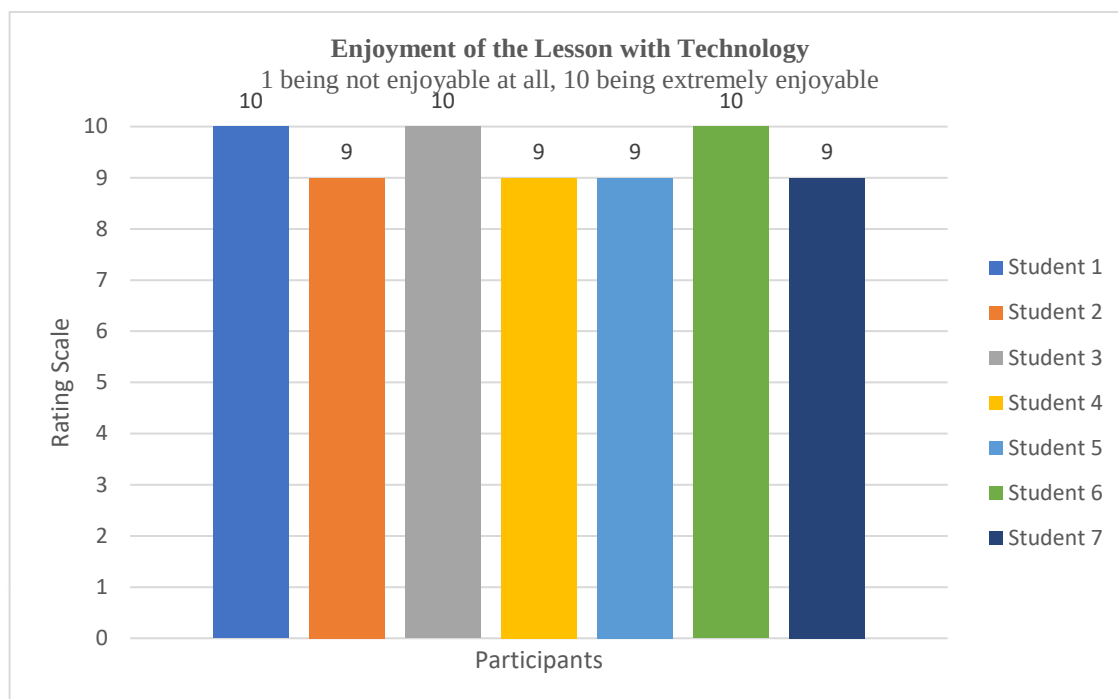
All the students unequivocally affirmed that the integrated technological tools within the science lesson have profoundly and positively contributed to their understanding of the lesson. A common thread running through their feedback was the profound influence of these technological tools on enriching their understanding. The majority of the students attributed their heightened understanding to the interactive nature of simulation activities, emphasizing how these virtual experiences seamlessly integrate real-world contexts, creating a more enjoyable learning environment. Moreover, several students noted that the integration of technological tools not only enhances learning but also makes it a more engaging and enjoyable experience.

3.2.5.3. *Enjoyment of the lesson with technology*

This theme underscores how the integrated technological tools enhanced the enjoyable aspect of the science lesson for the students. Table 18 presents the rating scale, depicting the level of enjoyment of the science lesson with technology after the second implementation.

Table 18. *Rating scale on the enjoyment of the lesson with technology during the second implementation*

Participants	Rating Scale									
	1	2	3	4	5	6	7	8	9	10
Student 1										✓
Student 2									✓	
Student 3										✓
Student 4									✓	
Student 5									✓	
Student 7										✓
Student 8									✓	



Graph 6. *Enjoyment of the lesson with technology during the second implementation*

Analysis of both Table 18 and Graph 6 reveals a striking trend in the students' ratings regarding the impact of integrated technological tools on the enjoyment of the science lesson. Students 1, 3, and 6 gave a perfect rating of 10, indicating that the technological tools significantly enhanced their overall enjoyment of the lesson. Furthermore, Students 2, 4, 5, and 9 were not far behind, offering a high rating of 9. This consistent trend among the students, with no ratings falling below 9, underscores the pervasive positive effect of the technological tools integrated into the science lesson. It is evident that a majority of the students found these tools to be instrumental in elevating the enjoyment of their learning experience.

The second part of the questionnaire introduced an open-ended question, inviting students to provide insights into how the integrated technological tools contributed to their enjoyment of the lesson. The responses gathered from the students revealed a spectrum of perspectives, and their diverse comments from the questionnaire are presented below.

Student 1 commented on how the integrated technological tools enhanced the overall enjoyment of the science learning experience. She expressed that these tools allowed her to conduct experiments more easily and understand the lesson more quickly. Student 1 captured this sentiment in the questionnaire as follows:

"I can do the experiments easily, and I can understand them fast." (Answer of Student 1 for the Third Question of the Second Week's Questionnaire).

Student 2 provided a clear expression of how the simulation activity they carried out collaboratively during the lesson contributed to her enjoyment of the lesson. 2's questionnaire entry is as follows:

"Because we are doing simulations and games, it can be enjoyable and fun at the same time." (Answer of Student 2 for the Third Question of the Second Week's Questionnaire).

Student 3 explicitly affirmed that the integration of technological tools into the science lesson significantly elevated the overall enjoyment of the learning experience for her. Further emphasizing her positive experience, she expressed her liking for the entire learning process. Additionally, Student 3 highlighted the use of mobile phones for the Kahoot activity during the assessment stage as particularly enjoyable. Furthermore, she expressed appreciation for the animated content incorporated into the lesson. This is what Student 3 recorded in her questionnaire:

"Yes, I liked it. It was also nice when we used phones for Kahoot. I also like the animation." (Answer of Student 3 for the Third Question of the Second Week's Questionnaire).

Student 4 expressed that the lesson became fun and advocated for the continued use of technological tools in the science lesson. This is what he wrote in the questionnaire:

"It was enjoyable and fun to do. I think we should do more of them." (Answer of Student 4 for the Third Question of the Second Week's Questionnaire).

Student 5 provided a clear and unequivocal statement in the questionnaire, affirming that the integrated technological tools in the science lesson significantly enhanced his overall enjoyment of the lesson because of playing games. This is what he wrote in the questionnaire:

"Yes, it is enjoyable because we played games." (Answer of Student 5 for the Third Question of the Second Week's Questionnaire).

Student 6 explicitly expressed that the integrated technological tools made the science lesson more fun and enjoyable. Student 6 specifically highlighted Kahoot as one of these tools. This is what Student 6 recorded in the questionnaire:

"Of course! The lesson is more fun and enjoyable. The technologies made the lesson more fun, especially Kahoot." (Answer of Student 6 for the Third Question of the Second Week's Questionnaire).

Student 7, in her response regarding the enjoyment of the science lesson with technology, described the technological tools as good and emphasized their significant assistance. She went on to elaborate that those tools made the lesson more enjoyable,

specifically attributing the enjoyable aspect to the Kahoot activity conducted during the assessment stage. Student 7's questionnaire entry is as follows:

"Good, because technology helped us a lot. It was enjoyable, and at the end of the lesson, we played Kahoot." (Answer of Student 7 for the Third Question of the Second Week's Questionnaire).

The feedback gathered from the students consistently reflected a positive feeling regarding how the integration of technological tools elevated their overall enjoyment of the science lessons. It is noteworthy that every student unequivocally recognized the contribution of these technological tools to the enjoyable nature of the lesson. A common thread in the students' responses was the positive influence of interactive games, particularly ESL Game Plus and Kahoot, utilized during the assessment of the lesson. Some of the students also emphasized the role of simulations in enhancing their enjoyment of the lesson. Furthermore, many students pointed out that the integration of technological tools not only heightened the enjoyment of the lesson but also made the entire experience more fun.

3.2.6. Findings from the semi-structured focus group interview

Following the completion of the science lesson, integrated with diverse technological tools, the students' feedback on their experience was solicited through a semi-structured focused group interview. Table 19 outlines the emergent themes and sub-themes from the semi-structured interview.

Table 19. *Themes and sub-themes emerged from the semi-structured interview during the second implementation*

Themes	Sub-Themes
1. Lesson Content	Speed
2. Utilization of Technological Tools	Types of Technological Tools Used Stages of Tool Usage
3. Impact of Technological Tools	Enhanced Understanding Enjoyable Learning
4. Feelings Toward Technology	Positive Emotions Increased Interest
5. Problems Encountered	No Problems Reported Slow Cursor Movement
6. Resolution of Encountered Problems	
7. Students' Views on the impact of Technology Integration in Science	Performance Improvement Fun Learning Enhanced Understanding More Engagement Varied Methods of Learning Visual Learning Impact and Preference Over Traditional Materials Advocacy for Continued Integration
8. Student Inquiries and Additional Comments	Student Questions and Requests

3.2.6.1. Lesson content

This theme sheds light on the topic treated during the science lesson, which involved the integration of various technological tools. The corresponding sub-theme provides a more detailed insight into the specific topic covered during the entirety of the lesson, namely, the concept of speed. The students articulated this during the interview as follows:

TEACHER: *What did you learn in class today?*

ALL STUDENTS: *Speed.*

3.2.6.2. Utilization of technological tools

This theme underscores the pivotal role played by the various technological tools integrated into the science lesson. The corresponding sub-themes offer valuable insights into the specific types of technological tools seamlessly integrated into the lesson. These included a video, animation, simulation, ESL Game Plus, and Kahoot. The second sub-theme delves into the temporal organization of these technological tools, categorizing their usage at distinct stages—beginning, middle, and end—providing a comprehensive view of the technological integration throughout the session. The interview dynamics between the teacher and students unfolded as follows:

TEACHER: *Second question, Student 2, were technological tools used in the lesson?*

Student 2: Yes. Should I say what they were?

TEACHER: What technological tools were used in the lesson?

Student 2: There was a video and an animation. And there was a simulation from PhET, ESL games, and Kahoot.

TEACHER: Thank you very much. Student 7, what do you think?

Student 7: We have some like video, animation, simulation from PhET, games, and Kahoot.

TEACHER: Okay. Thank you very much. So, the next question is, when were these technological tools and equipment used in the lesson? So, let's look at it this way. In the beginning of the lesson, Student 1, what technological tools did we use?

Student 1: We used video and animation. In the middle of the lesson, we did a simulation, and at the end, we did games and Kahoot.

3.2.6.3. Impact of technological tools

This theme elucidates the students' perspectives on the impact of the integrated technological tools on their understanding of the lesson. The first sub-theme emphasizes how these tools significantly enhanced their understanding of the lesson. The second sub-theme delves into the enjoyable aspects, highlighting how the tools made the lesson fun, aided visualization through animation, and contributed to effective learning. The sub-themes delve into how the integrated technological tools facilitated the students' understanding, expanded knowledge, and added an enjoyable dimension to the learning process, emphasizing the multifaceted positive impact of the tools on the students' educational experience. The interaction between the teacher and the students on the impact of technology on their learning is as follows:

TEACHER: The next question we are going to look at is: what impact did the technological tools used in the lesson have on your understanding of the lesson? So, let's begin with Student 1.

Student 1: They helped me understand better, and they made the lesson more enjoyable for me because I got to do it with my friends.

TEACHER: Thank you very much Student 1. Student 7, what about you?

Student 7: It helped me on how to calculate speed, distance, and time.

TEACHER: Thank you. Student 3?

Student 3: It expanded my knowledge about speed, distance, and time and how we can calculate them.

TEACHER: Okay, thank you. Okay, Student 4, on the same question, what impact did the technological tools used in the course have on your understanding of the lesson?

Student 4: It made me understand, but also in a fun way. And we also learned a lot, and I understood it more than we usually study.

TEACHER: Thank you very much. Student 6, what about you?

Student 6: It also helped me focus a lot better. And it helped me, like, understand the lesson and a topic in a fun way.

TEACHER: Okay. Thank you. Student 3, what about you?

Student 3: It helped me understand the topic better. And it was more interesting and fun than the usual lesson.

TEACHER: Thank you. Student 5?

Student 5: Teacher; same with others. It helped me understand the lesson. And funny.

TEACHER: And it's funny!

Student 5: Yeah.

3.2.6.4. Feelings toward technology

Under this theme, the students expressed their feelings towards the technological tools that were integrated into the science lesson. Two sub-themes emerged under this theme, which were positive emotion and increased interest. The sub-themes collectively elucidate the positive emotional impact of integrating technological tools in the classroom. The students consistently reported feeling happier, more engaged, and expressing a sense of enjoyment, attributing these feelings to the interactive and engaging nature of the technological tools. The interaction between the students and the teacher unfolded as follows:

TEACHER: The next question we are going to look at is: How did the technological tools we used in class make you feel? Yes, Student 1?

Student 1: I think the lesson was more fun than usual. Because I got to understand faster than usual.

TEACHER: Okay. Thank you. Student 7, what about you?

Student 7: The lesson's both funny and enjoyable.

TEACHER: Okay. Student 4, the question is, how did the use of technological tools in class make you feel?

Student 4: It made me feel great. And it also made me feel happy because, like, we had more fun.

TEACHER: Okay. Thank you. Student 6, what about you?

Student 6: Happy. And it made me, like, happy, yeah.

TEACHER: Can you explain a little bit why it made you feel happy?

Student 6: Because, so basically, the simulations and animations just, like, helped me focus better, and yeah, like, because of this technology.

TEACHER: Okay. Student 3, how did the technological tools make you feel?

Student 3: So, I felt better. Yeah, it was more interesting.

3.2.6.5. Problems encountered

This theme focuses on the problems the students encountered during the science lesson integrated with technological tools. Following the lesson, the majority of students generally expressed that they did not encounter any problems, indicating a seamless integration of the technological tools into the lesson. This constitutes the first sub-theme. The second sub-theme, slow cursor movement, highlights a specific challenge where two students, Student 4 and Student 6, expressed that they encountered a minor problem. According to these students, the mousepad was difficult to use, resulting in the slow movement of the cursor. The interaction between the students and the teacher regarding the problems encountered during the lesson unfolded as follows:

TEACHER: *While using technological tools in the lesson, did you encounter any problems?*

Student 2: *No, not at all. It was perfectly okay.*

TEACHER: *What about you, Student 1?*

Student 1: *No, I didn't face any problems. It was great.*

TEACHER: *Okay, Student 7, what about you?*

Student 7: *I didn't face any problems.*

TEACHER: *Okay. Student 5, did you face any problems regarding the technological tools we used?*

Student 5: *No.*

TEACHER: *Student 3, what about you?*

Student 3: *No.*

TEACHER: *Okay. So, Student 4, now with the problems you encountered during the lesson, you indicated that "there [was] a little problem with the computer, but I figured it out without any difficulties." What problem did you face?*

Student 4: *The mouse didn't work as much as I liked when I tried to use it, but I kind of figured it out.*

TEACHER: *Student 6. Did you face any problems regarding the technological tools we used?*

Student 6: *I mean, I guess it's a really small problem, but it doesn't really matter. It's just the mousepad. Like it doesn't. Sometimes, when I try to move it, the cursor doesn't move. That's it.*

TEACHER: *The cursor doesn't move.*

Student 6: *Yeah, it doesn't matter.*

3.2.6.6. Resolution of encountered problems

This theme delves into the ways in which the problems encountered by the students during the lesson were addressed. Two students reported problems with cursor movement.

However, upon further investigation, they revealed that they did not disclose these issues to the teacher during the lesson. Student 4 mentioned that he continued to use the mouse as it was, and eventually, it started working perfectly again. Student 6, on the other hand, stated that the problem was just minor and inconsequential. The interaction between the teacher and the students on how the problems encountered were resolved unfolded as follows:

TEACHER: Okay. So, Student 4, now with the problems you encountered during the lesson, you indicated that "there [was] a little problem with the computer, but I figured it out without any difficulties." What problem did you face?

Student 4: The mouse didn't work as much as I liked when I tried to use it, but I kind of figured it out.

TEACHER: Okay. Did you inform the teacher about this?

Student 4: No

TEACHER: So, how did you figure it out?

Student 4: I tried to use it a lot, and then it worked. Like it moved.

TEACHER: So, it worked perfectly in the end?

Student 4: Yes.

TEACHER: Student 6, back to this question: the problem regarding the cursor not moving—did you bring this problem to the attention of the teacher?

Student 6: No.

TEACHER: No? So, has anything been done to solve this problem?

Student 6: No.

3.2.6.7. Students' views on the impact of technology integration in science

This theme delineates the students' views on the impact of the integrated technological tools on their grades and overall performance in the science lesson. The sub-themes underscore the positive impact reported by the students, leading to improved grades and enhanced performance. Additionally, the use of interactive tools, such as the ESL Game Plus and Kahoot, along with varied methods of learning, is highlighted as instrumental in enhancing the students' understanding, engagement, and overall academic performance. The interaction between the teacher and the students on how the integrated technological tools impacted their grades and performance in the science lesson unfolded as follows:

TEACHER: The next question we are going to look at has to do with your grades and performance. The question is, has there been any change in your grades or performance since you started using technological tools in the lesson? So, let's look at it like this: Now,

with the performance and the grades, we can look at it in the ESL games you played and the Kahoot you played. Did the technology make you understand the lesson better? Did you get good grades in the Kahoot? And in the ESL game? So, let's begin with Student 2.

Student 2: *I think, yes, maybe a little, that it improved my performance, and I think I did well, better than last time.*

TEACHER: *Okay. Thank you. Student 1, what about you?*

Student 1: *I think I also improved, and in Kahoot, it was also fun, and I think it was better.*

TEACHER: *Okay. Student 3?*

Student 3: *I think that it improved, because last time, it wasn't that good. Like it improved.*

TEACHER: *Okay. Student 4, what about you?*

Student 4: *I think it also improved.*

TEACHER: *In what way?*

Student 4: *In a fun way.*

TEACHER: *In a fun way! Okay. Student 6?*

Student 6: *I think it has improved my grades. Because it helps me, like it's more interesting. The lesson's become more interesting. And I think it has helped me improve my grades.*

TEACHER: *Okay, thank you very much.*

Student 6: *You are welcome.*

TEACHER: *What kind of change did you see in your grades? And what kind of change did you see in your performance? As a result of the tools we used.*

Student 1: *I think I was able to answer the questions a lot faster because I understood the topic better. And the Kahoot especially helped me a lot.*

TEACHER: *Thank you very much. Okay. Student 7, what do you think?*

Student 7: *I think Kahoot helped me much better to understand because it helped me to be able to answer faster.*

TEACHER: *Okay. Thank you very much. Student 3, could you explain what kind of change occurred as a result of the technological tools we used regarding your grades and performance?*

Student 3: *I am improved. Something actually changed.*

TEACHER: *What's changed?*

Student 3: *Nothing. It was more interesting. That's all.*

TEACHER: *Student 4, can you explain what kind of change occurred in your grade and performance?*

Student 4: *I think it changed a little bit.*

TEACHER: *How?*

Student 4: *Because it made me understand a lot. Because of different methods of learning.*

TEACHER: *What kind of methods?*

Student 4: *I think technological tools, videos, animations, and simulations from PhET. All of them, like, helped me improve.*

Additionally, the students have expressed diverse views and regarding the integration of technology in the science teaching and learning process. The overall views expressed by the students are that science lessons integrated with technological tools are not only enjoyable but also significantly contribute to their understanding of complex science topics. The students particularly value the visual impact of learning, emphasizing the benefits derived from videos, animations, and simulations. Notably, a discernible shift in preference emerged as the students clearly expressed an inclination towards technology over traditional learning materials, deeming traditional books as dull in comparison. Furthermore, the specific mention of preferred tools, such as simulations from PhET and Kahoot, provided a detailed insight into their preferences, revealing a nuanced understanding of the effectiveness of specific technological resources. The interaction between the teacher and the students regarding their general views on integrating technological tools into the science lesson is presented as follows:

TEACHER: *Thank you very much. So, the last question is, what do you think about the use of technological tools in science lessons? Should we continue to use them? Or should we stop using them? And why should we continue to use them? Or why should we stop using them?*

Student 2: *I think we should continue using them a lot because they make the lesson a lot more enjoyable that way. And that's because some people don't just simply learn with the book, like me. So, my understanding improved when we used technological tools. So yeah, I think we should continue with them.*

TEACHER: *Thank you very much Student 2. Student 1, what do you think?*

Student 1: *I think we should continue because it makes the lesson a lot more fun. And, like, I can see how the experiment is done with the video, animation, and simulation. I think it's really good.*

TEACHER: *Okay. Thank you. Student 7, what about you?*

Student 7: *In my opinion, the book is kind of boring and not interesting. But when you're using technology tools, it's much more fun and enjoyable.*

TEACHER: *Thank you very much. Okay, Student 5, the question is, what do you think about the use of technological tools in science lessons? Should we continue to use them? Should we stop using them? And why?*

Student 5: *Yeah, because it's helping me understand the lesson. Animation and videos are helping.*

TEACHER: *Okay. Thank you very much. Student 3, what do you think?*

Student 3: *I think we should continue using technological tools because it's more interesting that way, and you can understand the topic better.*

TEACHER: *Thank you very much. Student 4, what about you?*

Student 4: *I think we should do it more.*

TEACHER: Why?

Student 4: Because it's a fun way to learn with, like, a lot of people, your friends, and your classmates.

TEACHER: The question has to do with: What do we think about the use of technological tools in science lessons? Should we continue to use technological tools?

Student 4: We should.

TEACHER: Why?

Student 4: It's a funny way, it's another way to learn.

TEACHER: The question is, what do you think about the use of technological tools in science lessons?

Student 6: The use of technology? Yeah, I think we should keep using it because it's more interesting and helps us learn better. They should stay. And we should keep using the technological tools, especially simulations from PhET and Kahoot.

3.2.6.8. Student inquiries and additional comments

This theme emphasizes occasions during the interview where the students raised inquiries and presented requests concerning the integrated technological tools during the science lesson. The students exhibited curiosity about when they could participate in the ESL Game Plus and Kahoot activities, showcasing their keen interest and enthusiasm for the interactive learning experience. The teacher responded by indicating that the ESL Game Plus and Kahoot would likely be incorporated into the next lesson. This sub-theme underscores the students' proactive engagement in the learning process, as they sought clarification and expressed anticipation for specific activities, such as playing ESL Game Plus and Kahoot.

TEACHER: Okay, thank you very much. So, I think that's the end of the interview. However, if you have anything you would like to say to me, anything you would like to contribute, you are welcome. So, Student3?

Student 3: When are we going to do Kahoot again?

TEACHER: In our next lesson, we'll do Kahoot.

Student 5: Can we do more Kahoot?

TEACHER: Yeah, we will do more Kahoot in our next lesson. Yes, Student 4. Any question? Student 7?

Student 7: In the next lesson, can we play some ESL games?

TEACHER: Yeah, we'll play some ESL games in the lesson. I think that's all for now. Thank you very much for your contribution.

ALL STUDENTS: You're welcome.

3.2.7. Findings from the researcher's post-implementation reflection journal

After the science lesson integrated with technological tools, the researcher recorded a post-implementation reflection journal, detailing his perspective on the lesson's execution and outcomes. The information from the researcher's post-implementation reflection journal was categorized into themes and analyzed descriptively. Here are the themes that emerged from the researcher's post-implementation reflection journal:

1. Successful Integration of Technological Tools
2. Students' Understanding and Engagement
3. Positive Students' Feedback
4. Addressing Students' Challenges and Concerns

3.2.7.1. *Successful integration of technological tools*

Under this theme, the researcher highlighted the successful integration of diverse technological tools into the science lesson, encompassing a video, animation, simulation, ESL Game Plus, and Kahoot. Furthermore, the researcher conveyed contentment with the seamless implementation, highlighting the favourable influence of the technological tools on the students' understanding and enjoyment of the lesson. This is what the researcher documented in the post-implementation reflection journal.

"I hope everything is going well with you. I'm here again to share details about the morning session I conducted. I'm pleased to report that I successfully incorporated all the planned technological tools into the lesson, including a video, animation, simulation, ESL game, and Kahoot. Additionally, I'm happy to state that, based on my observations, the students really understood and enjoyed the lesson, all thanks to the integrated technological tools." (Ankara, 27th November, 2023, Line Number: 1-5).

3.2.7.2. *Students' understanding and engagement*

Under this theme, the researcher elaborated on the observations he made regarding the students' understanding and engagement during the science lesson. The researcher expressed that the students not only enjoyed the content presented through the video and animation but also demonstrated a clear understanding of the topic of speed. According to the researcher, the collaborative engagement during the simulation task further showcased the students' understanding of the lesson, as evidenced by the questions raised by the students during discussions of the lesson and their overall demeanour. The researcher elaborated on this as follows:

“At the beginning of the lesson, I displayed a video and animation on the smartboard, providing a detailed and clear explanation of the topic under discussion, which was speed. From my observations, it was evident that the students not only enjoyed the content but also understood the information conveyed, as seen from the questions they raised and their overall demeanour. Midway through the lesson, the students collaboratively engaged in a "moving man" simulation task on their laptops, manipulating the figure and calculating speed, distance, and time. Finally, at the end of the lesson, the ESL Game Plus and Kahoot were employed to assess the students' understanding of the lesson. The ESL Game Plus was completed collaboratively, while the Kahoot was done individually. I must say, I am genuinely impressed with the students' performance.” (Ankara, 27th November, 2023, Line Number: 6-15).

3.2.7.3. Positive students' feedback

Under this theme, the researcher delved into the students' performance and feedback following the science lesson integrated with technological tools. The researcher noted that the students demonstrated outstanding performance during the lesson. Furthermore, the researcher pointed out that the students' questionnaire ratings reflected minimal challenges (rated 1 or 2), high effectiveness in contributing to understanding (mostly rated 9 or 10), and high enjoyment (mostly rated 9 or 10). The researcher documented this as follows:

“After the implementation, the students completed a three-question questionnaire that included a rating scale, assessing how the integrated technological tools presented challenges or problems, enhanced their understanding, and increased their enjoyment of the lesson. With only seven students participating in the lesson, their feedback was overwhelmingly positive. Regarding the challenges posed by the integrated tools, on a scale of 1–10 (where 1 denotes very easy and 10 denotes very difficult), five students selected 1, while two students chose 2 and 4. On the effectiveness of technology's contribution to understanding (on a scale of 1–10, where 1 denotes not very effective at all and 10 denotes extremely effective), four students selected 10, and three students chose 9. Finally, in terms of enjoyment (on a scale of 1-10, where 1 denotes not enjoyable at all and 10 denotes extremely enjoyable), three students chose 10, and four students selected 9.” (Ankara, 27th November, 2023, Line Number: 16-26).

3.2.7.4. Addressing students' challenges and concerns

Under this theme, the problems that the students encountered during the lesson were expounded upon. As per the researcher's findings, only two students mentioned facing challenges, specifically with a slow cursor movement. The researcher detailed the

methods used to collect data on the problems experienced by the students, utilizing a questionnaire, an exit ticket, and semi-structured interviews. The researcher emphasized that the implementation proceeded as planned without facing any challenges personally. However, due to the students not reporting these problems to the teacher during the lesson, the teacher remained unaware, and consequently, no actions were taken to address them. The researcher documented this as follows:

“The questionnaire, exit ticket, and semi-structured interview were designed to gather information from the students regarding their perspectives on the lesson. The students provided notably impressive responses, offering valuable insights. This process also served as an opportunity to delve further into the problems encountered by some students, specifically addressing the individual who rated the difficulty as 4 on the questionnaire. This student highlighted issues with the laptop cursor not moving to their liking. Additionally, the student who rated the difficulty at 2 shared that he faced a problem with the laptop’s cursor but managed to resolve it independently. Personally, I did not encounter any challenges or problems during the implementation, and everything unfolded as planned. That is all for now, dear diary. Until later.” (Ankara, 27th November, 2023, Line Number: 27-36).

3.2.8. Findings from validity committee meeting records

After each lesson, the researcher collected a series of data about how the lesson went, focusing particularly on the problems encountered and how these problems were addressed. Subsequently, a meeting was convened with the validity committee members to deliberate on the problems encountered during the lesson and propose solutions to those problems. Table 20 presents the problems encountered during the second implementation and the decisions taken by the validity committee members to address them.

Table 20. Second Implementation Issues and Validity Committee Decisions

Related Week	Encountered Problems	Action Decisions Taken to Solve Problems	VCM		
			No:	Mins	P
2 nd Week	The students who had mobile phones completed the assessment task on Kahoot individually, while those without mobile phones worked on it collaboratively. As a result, the individual performance of the students could not be assessed.	The "Bring Your Tablet" model was recommended, wherein parents were informed to permit students to bring their phones to school for the assessment task.	2	90	4
	The technological tools integrated into the lesson were quite basic and developed by others.	It was recommended that the researcher make an effort to develop and integrate at least one advanced technological tool independently.			

VCM: Validity Committee Meeting; No: Meeting No; Mins: Meeting Duration (Minutes); P: Number of Participants

At the assessment stage of the lesson, the intention was to evaluate both the individual and collaborative performance of the students. Consequently, ESL Game Plus was employed for collaborative assessment, conducted on laptops, while Kahoot was utilized for individual assessment. Collaborative assessment through the ESL Game Plus proceeded smoothly, with the students completing the tasks on their laptops. However, some students did not have their mobile phones, resulting in pairing them with students possessing phones for the Kahoot activity for the individual assessment. This unintended collaboration posed an issue as it hindered the individual assessment of the students. To address this challenge, validity committee member 2 recommended implementing the "Bring Your Tablet" model. This is what validity member 2 said:

"There is a "Bring Your Tablet" program abroad, especially in Europe and America. Students are informed beforehand to bring their tablet devices to class. It is explained that technology will be used in class that week, and they will need to bring their tablets to the classroom. We need to implement this model, ensuring that every student brings their device to class." (VCM No. 3).

In this model, parents were reminded to permit their children to bring their phones to school for specific activities, facilitating the individual assessment of the students.

Various technological tools were integrated into the science lesson, including a video, animation, simulation, ESL Game Plus, and Kahoot. All these tools were open-access and freely and readily available on the internet. Validity committee member 2 suggested that the researcher take on the challenge of developing and integrating at least

one advanced technological tool independently. The suggestion stemmed from the observation that the existing tools were deemed too basic and outdated. This is what validity committee member 2 said:

“You can use a different medium. You can use a different tool. You can use 3D simulation. These are very old technologies [the ones you are currently using]. We try to keep up with current technology. If you can find an alternative, better virtual lab and three-dimensional simulation, I think you will be able to make this subject much better for the children.” (VCM No. 3).

The researcher was encouraged to explore the creation of 3D simulations, interactive videos, virtual reality, and similar innovations to introduce a higher level of technological sophistication into the lesson. This step aligns with the overarching goal of the research, which focuses on integrating technology into science education.

3.3 Findings from the Third Week of Implementation

The third action plan was developed based on the decisions made by the committee, leading the researcher to revise the lesson plan. The revisions for the third week's implementation process were as follows:

1. The “Bring Your Phone to School” model was implemented, where all students were asked to bring their phones for individual assessment through Kahoot.
2. A 3D simulation was developed and integrated by the researcher using the CoSpacesEdu platform.

The data collected from various sources following the third implementation is presented in this section. Data were gathered from three primary sources: the researcher, students, and members of the validity committee. The collected data encompassed the researcher's pre-implementation reflection journal, observation field notes, observation protocol, students' reflection journals, questionnaires, semi-structured interviews, the researcher's post-implementation reflection journal, and records from the validity committee meetings. The findings derived from the data are presented chronologically, addressing the beginning, middle, and end phases of the implementation.

Table 21. *Summary of the lesson plan, technological tools, and the data collection instruments utilized throughout the third implementation*

Course Title	Science
Class	7 th Grade
Unit	Unit 3: Forces and Energy
Topic	3.3: Describing Movement
Time	80 Minutes
Date	4 th December, 2023
Course Book	Cambridge Lower Secondary Science Learner's Book 8
Learning Objectives	By the end of the lesson the students will be able to: • Learn how to use graph to describe movement. • Understand what distance/time graph shows. • Learn how to draw a distance/time graph.
Technology Integration Tools	• Interactive video • 3D Simulation • Kahoot
Data Collection Instruments Utilized Throughout the Implementation	1. Researcher's pre-implementation reflection journal 2. Observation field note 3. Observation protocol 4. Students' reflection journal 5. Questionnaire 6. Semi-structured focus group interview 7. Researcher's post implementation reflection journal 8. Validity committee meeting records

Table 21 presents a summary of the lesson plan, outlining the learning objectives, technological tools, and data collection instruments employed during the third implementation. The lesson spanned 80 minutes, equivalent to two class periods, and focused on the topic of describing movement within unit three of forces and energy from the Cambridge Lower Secondary Science Learner's Book 8. Conducted on December 40, 2023, with 7th-grade students, the learning objectives aimed for students to learn how to use graphs to describe movement, understand what a distance/time graph shows, and learn to draw a distance/time graph. The technological tools integrated included an interactive video, 3D simulation, and Kahoot. Lastly, the data collected during this implementation encompassed the researcher's pre-implementation reflection journal, observation field notes, observation protocol, students' reflection journals, questionnaire, semi-structured interview, researcher's post-implementation reflection journal, and records from validity committee meetings.

3.3.1. Findings from the researcher's pre-implementation reflection journal

Prior to the lesson, the researcher recorded a reflective journal outlining planned activities, which served as a guiding blueprint for the lesson. The journal detailed the rationale for integrating technological tools into the science lesson, including specifics on the selected tools, their sources, and the targeted science topic and objectives. It further elaborated on the implementation process, detailing tool integration at the beginning, middle, and end of the lesson, along with hardware and software considerations. The journal also outlined strategies for assessing the students' understanding and expressed the researcher's confidence in managing the lesson and addressing emerging problems. The ensuing analysis identified eight themes, providing insights into planning and anticipating challenges in integrating technological tools into the science lesson. The emerging themes are presented below:

1. Purpose of Implementation
2. Focused Technology Integration
3. Technological Tools and Their Sources
4. Lesson Structure and Content
5. Technology Integration Process and Phases
6. Utilization of Technological Devices
7. Post-Lesson Feedback and Reflection
8. Confidence and Caution in Implementation

3.3.1.1. Purpose of implementation

Within this theme, the researcher emphasized the overarching objective of the entire implementation—a science lesson seamlessly integrating various technological tools. The researcher underscored the implementation's objective: refining instructional practices, exploring effective methods of incorporating technological tools into science lessons, and assessing how these tools will enhance the students' understanding and enjoyment of the science lesson. This sentiment, recorded in the pre-implementation reflection journal, articulates the researcher's purpose and aspirations for the upcoming lesson.

"I hope you are doing well today. I am writing to you with enthusiasm once again, eager to share details about my upcoming implementation scheduled for Monday, December 4, 2023. The objective for this implementation remains unchanged: to refine my teaching practices, explore effective methods of integrating technological tools into science lessons, and assess

how these tools will contribute to the students' understanding and enjoyment of the science lesson.” (Ankara, 3rd December, 2023, Line Number: 1-5).

3.3.1.2. Focused technology integration

Within this theme, the researcher provided insights into the reasoning behind selecting specific technological tools and their subsequent integration into the lesson. The researcher characterized this decision as deliberate, aiming to avoid overwhelming the students or consuming excessive time during the technological tool integration. Instead, a strategic approach to technological tool selection was emphasized. The researcher stressed the significance of prioritizing quality over quantity and opting for specific tools—such as an interactive video, 3D simulation, and Kahoot—for integration into the lesson. This approach reflects the researcher's conscientious effort to amplify the impact of technology on the intended learning outcomes. This is what the researcher recoded in the pre-implementation reflection journal in that regard:

“In the upcoming implementation, my focus will not be on integrating a plethora of technological tools into the lesson. Instead, the lesson's objective, centered around describing movement, requires ample practice, detailed movement descriptions, and calculations. Consequently, my emphasis will be on this objective, strategically selecting technological tools to enhance its achievement. Within the framework of this implementation, I plan to integrate a video, a 3D simulation, and Kahoot.” (Ankara, 3rd December, 2023, Line Number: 6-12).

3.3.1.3. Technological tools and their sources

Under this theme, the researcher provided a detailed account of the envisioned technological tools slated for integration into the science lesson and their respective sources. As per the pre-implementation reflection journal, these tools include an interactive video from YouTube ([http-3](#)), a self-developed 3D simulation on the CoSpacesEdu ([http-6](#)) platform, and personally crafted questions for Kahoot ([http-5](#)) assessment. It's noteworthy that, despite the availability of a paid version of Kahoot, the researcher deliberately opted for the free version. The researcher underscored that these tools were intentionally chosen to enhance the learning experience, aiming to maximize the students' understanding and enjoyment of the lesson's content. This is what the researcher recorded in the pre-implementation reflection journal:

“Within the framework of this implementation, I plan to integrate a video, a 3D simulation, and Kahoot. The interactive video, sourced from YouTube, will engage the students by posing questions, pausing for reflection, and then proceeding to provide answers and explanations. This dynamic format is expected to greatly benefit the students. Additionally, I have developed a 3D simulation using CoSpacesEdu, aiming to facilitate hands-on tasks for the students. This simulation, personally crafted, aligns perfectly with the lesson's objectives. Lastly, while Kahoot offers a paid version, I will be utilizing the free version and have independently created a set of questions for use on the platform. This combination of tools is chosen intentionally to enrich the learning experience and maximize the students' understanding and enjoyment of the lesson's content.” (Ankara, 3rd December, 2023, Line Number: 10-20).

3.3.1.4. Lesson structure and content

According to the researcher's entry in the pre-implementation reflection journal, the selected science topic for integrating various technological tools is "describing movement." The researcher characterized this topic as straightforward, indicating that the students will primarily be tasked with graphing the movement of an object on a distance/time graph. However, the researcher highlighted the challenge inherent in the topic, particularly in the intricacies of graphing movements on a distance/time graph and the calculations involving speed. This theme underscores the perceived complexity of the chosen topic and emphasizes the necessity for a well-structured lesson plan incorporating technological tools to effectively address the challenges associated with these concepts.

“The integration of technological tools in the upcoming lesson will centre around the topic of describing movement. This concept is fundamentally about the movement of an object, then graphing the movement on a distance/time graph. Some concepts, like constant speed, steeper speed, slowing down, and a body at rest or stationery, will be expatiated. While the concept itself is straightforward, the challenging aspect of the lesson lies in the graphing of movements on the distance/time graph and the calculations involving speed.” (Ankara, 3rd December, 2023, Line Number: 21-26).

3.3.1.5. Technology integration process and phases

This theme underscores the systematic integration of various technological tools across distinct phases of the lesson, encompassing the beginning, middle, and end. The researcher strategically plans to incorporate an interactive video at the beginning of the lesson, a 3D simulation in the middle, and Kahoot at the end of the lesson. As outlined in the researcher's pre-implementation reflection journal, the interactive video is intended for integration at the beginning of the lesson, aiming to elucidate the fundamental concept

of the topic slated for discussion during the session. This approach reflects a purposeful sequencing of technological tools to align with specific instructional objectives at different stages of the lesson. The researcher captured this as follows:

“To aid in understanding, an interactive video will be presented at the beginning of the lesson to elucidate the fundamental concept of a distance/time graph.” (Ankara, 3rd December, 2023, Line Number: 27-28).

In the middle of the lesson, the researcher intends to integrate a 3D simulation where the students will engage in a task involving making an object move at various speeds—constant, steeper, stationary, and slower. The task will also involve graphing these movements on a distance/time graph. The researcher highlighted in the pre-implementation reflection journal that, before introducing the 3D simulation, the students will receive step-by-step instruction on how to perform the task effectively. Subsequently, following the completion of the 3D simulation task, the students will be provided with a worksheet. This worksheet will require them to graph the movements observed in the 3D simulation on a distance/time graph and engage in calculations related to speed. This comprehensive approach will ensure a practical application of the concepts learned during the lesson. The researcher captured this as follows:

“In the middle of the lesson, I will demonstrate the step-by-step procedure for executing a 3D simulation. This simulation, to be carried out collaboratively on the students' laptops, aims to provide a hands-on experience in making an object move at constant speed, steeper speed, stationary speed, and slower speed. After completing the 3D simulation task, the students will work on a worksheet. This worksheet will require them to graph the movement from the 3D simulation task on a distance/time graph and subsequently use the graph to calculate the speed of the object. This multifaceted approach will ensure that the students will not only grasp the theoretical aspects of the concept but also engage in practical application and calculations for a comprehensive understanding.” (Ankara, 3rd December, 2023, Line Number: 28-36).

At the lesson's conclusion, the researcher plans to utilize Kahoot for individual student assessment. This assessment will be conducted individually, with the students using their mobile phones. As per the researcher's rationale, this form of assessment aims to evaluate the students' capability to independently complete the task without relying on peer or teacher support. The chosen method emphasizes individual understanding and proficiency, providing insights into each student's independent understanding of the lesson's content. The researcher captured this as follows:

“At the end of the lesson, thus, at the assessment stage, the students will actively participate in an individual assessment using Kahoot. The assessment will comprise fifteen questions that will cover the entirety of the lesson, accessible on their smartphones. The individual completion of the Kahoot will serve as a direct measure to assess each student's independent understanding of the lesson. This approach will evaluate their ability to answer questions autonomously without relying on peer or teacher scaffolding.” (Ankara, 3rd December, 2023, Line Number: 37-42).

3.3.1.6. Utilization of technological devices

This theme details the essential hardware components utilized to support the technological tools in the lesson. According to the researcher's pre-implementation reflection journal entry, the hardware includes two laptops, a smartboard, and smartphones. The smartboard will be used to display various tools, such as the Cambridge Lower Secondary Science Stage 8 software, interactive video, 3D simulation, and Kahoot. The laptops will be utilized by the students for collaborative completion of the 3D simulation task. Lastly, the students will employ their mobile phones for individual completion of the assessment task on Kahoot. The researcher documented these details as follows:

“In the upcoming lesson, a range of technological devices will be employed, including two laptops, a smartboard, and smartphones. The smartboard will function as the primary display for various technological tools, including the Cambridge Lower Secondary Science Stage 8 software, interactive video content, and 3D simulations. The students will actively engage in the collaborative 3D simulation task using their laptops. Furthermore, the individual completion of the Kahoot task will be facilitated through the use of smartphones.” (Ankara, 3rd December, 2023, Line Number: 43-48).

3.3.1.7. Post-lesson feedback and reflection

This theme explores the post-lesson data collection planned by the researcher. Following the conclusion of the lesson, the researcher intends to employ diverse methods, including a questionnaire, students' reflection journals, and semi-structured focus group interviews, to gather comprehensive information from the students regarding their experiences with the lesson. As per the researcher's perspective, these data collection tools are anticipated to yield detailed insights into the challenges the students encountered during the lesson and elucidate how the integrated technological tools contributed to their understanding and enjoyment of the lesson. Furthermore, the interviews and the students'

reflections are designed to provide nuanced information on the overall perceptions of the students concerning the integration of technology into science lessons. Finally, the researcher expressed the intention to meticulously document all occurrences during the lesson through observation field notes, capturing the intricacies and dynamics of the teaching and learning process. The researcher documented these details as follows:

“After the lesson, I intend to gather comprehensive feedback from the students using a structured three-question questionnaire featuring a rating scale. This will enable them to share their insights regarding the challenges they will encounter with the integrated technological tools and how these tools will contribute to both their understanding and enjoyment of the lesson. Additionally, an exit ticket in the form of a reflection journal will be employed, inviting the students to express their individual views and perceptions about the lesson. To delve deeper into their experiences, I plan to conduct a focus group interview with the students. This interactive session aims to solicit insights that will not be easily captured by the questionnaire and exit ticket, providing a more nuanced perspective. Immediately following the implementation, I will diligently document my observations, capturing the intricacies of the lesson. This observation field note will serve as a valuable resource, facilitating the completion of the observation schedule and allowing for reflection on the overall effectiveness of the implemented technological tools.” (Ankara, 3rd December, 2023, Line Number: 49-61).

3.3.1.8. Confidence and caution in implementation

This theme reflects the researcher's confidence derived from past implementation. According to the researcher, the experience he gained from the previous implementation has given him the confidence that he will be able to successfully integrate the various technological tools into the lesson and also address any challenges that will emerge. The researcher also tried to balance confidence with caution, which highlights the researcher's commitment to meticulous attention to details and flawless execution as a top priority throughout the implementation. The researcher captured this as follows:

“Dear Diary, this time around, I find myself filled with confidence that everything will unfold according to plan. Drawing from the experiences of previous implementations, I believe I am well-prepared to handle any unforeseen events that may arise. While my confidence is high, I recognize the importance of proceeding with caution, taking things slowly, and paying meticulous attention to details. Ensuring each section of the implementation is executed flawlessly is my priority.” (Ankara, 3rd December, 2023, Line Number: 62-67).

3.3.2. Findings from the researcher's observation field note

The data from the observation field note underwent analysis, resulting in the emergence of seven themes and their respective sub-themes. Various patterns, recurring topics, and significant concepts derived from the observation field notes served as references in forming these themes and sub-themes. The themes and sub-themes that emerged from the observation field notes are presented in Table 22.

Table 22. *Themes and sub-themes emerged from the researcher's observation field note during the third implementation*

Themes	Sub-Themes
1. Lesson Preparation and Classroom Setup	Organization of Classroom Space Technological Tools Setup Students' Population
2. Introduction and Instructional Objectives	Communication of Instructional Objectives Getting Started Technological Tools Integration
3. Interactive Video and Cambridge Lower Secondary Science Software	Interactive Video Presentation Cambridge Lower Secondary Science Software
4. 3D Simulation and Hands-On Activities	Step-by-Step Instruction Coding and Graphing Visualization and Comprehension
5. Assessment with Technological Tools	Kahoot Assessment
6. Problems Encountered and Their Solutions	No Problems Encountered Adaptations During the Lessons
7. Reflection and Adaptations	Post-Lesson Reflection

3.3.2.1. Lesson preparation and classroom setup

This theme emphasizes the preparations and classroom adjustments made by the researcher prior to the science lesson, integrated with various technological tools. Within the first sub-theme that emerged, the researcher elaborated on the transformation of the classroom seating from traditional rows into two cooperative groups, thereby creating an optimal learning environment for the students. The researcher details this process as follows:

"I entered the classroom at around 10:10 am to conduct a science lesson on the topic of describing movement for 7th-grade students. Equipped with two laptops, the Cambridge Lower Secondary Science Stage 8 textbook, printed questionnaire papers, and worksheets, I began by rearranging the classroom seating between 10:10 and 10:20 am. I organized the desks into two groups, both with four seats." (4th December, 2023, Observation Field Note, Line Number: 1-5).

The second sub-theme within this category centers on the setup of the technological tools before the science lesson. This encompassed the opening and logging into the

smartboard and the students' laptops, as well as the preparation of the Cambridge Lower Secondary Science Stage 8 software, an interactive video from YouTube, a 3D simulation on CoSpacesEdu, and Kahoot. This procedure aimed to ensure that all devices and software were prepared and operational for use before the lesson. The researcher documented this process as follows:

"Additionally, I set up the students' laptops in front of each group, opened and launched the Cambridge Lower Secondary Science Stage 8 software, a video from YouTube, a 3D simulation from CoSpacesEdu, and Kahoot on the smartboard." (4th December, 2023, Observation Field Note, Line Number: 5-7).

Finally, after organizing the classroom spaces and confirming that all the technological tools intended for integration into the lesson were prepared and operational, the researcher provided details on the student population set to participate in the lesson. The researcher articulated this aspect as follows:

"The class had eight students—four males and four females—who were present in the classroom." (4th December, 2023, Observation Field Note, Line Number: 7-8).

3.3.2.2. Introduction and instructional objectives

This theme centers on the introduction phase of the science lesson integrated with technological tools, emphasizing engaging the students and establishing clear instructional objectives. The first sub-theme that emerged, "communication of instructional objectives," highlights how the researcher conveyed the lesson's objectives to the students before any active lesson commenced. The researcher mentioned that the Cambridge Lower Secondary Science Stage 8 software was opened on the smartboard, and the instructional objectives were communicated to the students. This strategy is crucial, as articulating, writing, or displaying the instructional objectives for students before any lesson is of great significance. The researcher details this process as follows:

"Following that, between 10:20 and 10:25 am, I opened the Cambridge Lower Secondary Science Stage 8 software and presented it on the smartboard. During this time, I communicated the instructional objectives of the lesson to the students." (4th December, 2023, Observation Field Note, Line Number: 9-11).

Under the second sub-theme, "getting started," the researcher elaborated on the brief question-and-answer session held with the students to assess their relevant prior knowledge before the lesson. The researcher expressed that the students demonstrated impressive relevant prior knowledge owing to the close relationship between their

previous topic and the current one, enabling them to participate in the lesson without any difficulty. The researcher details this process as follows:

“In the “getting started” stage of the lesson, a brief question-and-answer session was conducted to assess their relevant previous knowledge related to the lesson. Based on my observation, the students demonstrated a solid understanding of the topic, as evidenced by their impressive responses. Their strong relevant prior knowledge resulted from the close relationship between the previous topic and the current one, both being based on the same concept of forces and motion.” (4th December, 2023, Observation Field Note, Line Number: 11-16).

Under the sub-theme, Technological Tools Integration, the researcher took the opportunity to introduce and brief the students on the specific technological tools that would be integrated into the lesson to enhance their learning experience during the lesson. Clear communication about when and how these tools would be integrated was emphasized, ensuring that the students were well-informed and prepared for each phase of the lesson. This proactive approach aimed to create a seamless and engaging learning environment, fostering a sense of confidence and understanding among the students regarding the forthcoming technological tools. The researcher details this process as follows:

“Furthermore, I informed the students about the technological tools that would be integrated into the lesson and explained when each tool would be introduced and utilized.” (4th December, 2023, Observation Field Note, Line Number: 16-18).

3.3.2.3. Interactive video and Cambridge lower secondary science software

This theme delves into the integration of multimedia tools to elevate the learning and comprehension of the students' scientific concepts. The first sub-theme that emerged focuses on the integration of an interactive video aimed at influencing and enhancing the students' participation during the lesson. The interactive nature of the video prompted strategic pauses, allowing the students to engage in calculations independently. Subsequently, the answers and the calculation processes were elucidated, fostering a dynamic and participatory learning environment. This approach not only ensured the active involvement of the students but also facilitated a deeper understanding of the scientific content being presented. The researcher captured this observation as follows:

“From 10:25 to 10:35 am, a brief interactive video on describing movement on a distance/time graph, sourced from YouTube, was presented to the students using the smartboard. The students were quiet and engaged, attentively watching the video. Due to the

interactive nature of the video, there were pauses, allowing the students to carry out tasks such as calculating speed using the distance/time graph. Subsequently, the video continued, revealing the answers and explaining the processes involved in the calculations. The students really enjoyed the interactive video and actively participated in the tasks, collaborating and offering support to one another.” (4th December, 2023, Observation Field Note, Line Number: 19-25).

The second sub-theme explores the utilization of the Cambridge Lower Secondary Science Stage 8 software to delve into the concept of a distance/time graph. At this phase, the students were guided through diverse types of speeds, modelled these variations, and actively participated in calculations related to speed. This interactive use of software not only facilitated a comprehensive exploration of the topic but also provided the students with a practical and engaging platform to grasp the intricacies of distance/time graphs and speed calculations. The researcher captured this as follows:

“Following the interactive video presentation, around 10:35 am, the lesson in the Cambridge Lower Secondary Science Stage 8 software was displayed on the smartboard and discussed with the students. In this segment, the concept of the distance/time graph was elaborated upon. We explored different kinds of speed on the distance/time graph, including constant speed, steeper speed, slowing down, and a body at rest. Subsequently, we worked through some examples from the Cambridge Lower Secondary Science Stage 8 software on the smartboard, describing and modeling these types of movements in the classroom, and graphing the movements on a distance/time graph on the whiteboard.” (4th December, 2023, Observation Field Note, Line Number: 26-33).

3.3.2.4. 3D Simulation and hands-on activities

This theme delves into the hands-on dimension of the lesson, with a specific focus on the 3D simulation and coding tasks carried out. The first sub-theme underscores the in-depth explanation and step-by-step demonstration provided by the researcher for the 3D simulation task. This involved guiding the students through the coding process for various movements within the CoSpacesEdu platform, followed by illustrating how these movements could be graphed on the distance/time graph. Through this detailed demonstration, the students gained a precise understanding of coding techniques and the execution of the 3D simulation task, contributing to their practical application and comprehension of the lesson. The researcher elaborated on this process as follows:

“Subsequently, at approximately 10:45 am, I provided the students with a detailed explanation and step-by-step demonstration for a 3D simulation task I developed on the CoSpacesEdu platform. In this stage, I demonstrated to the students how to code to make a

body move in the simulation. Within the coding framework, I showed the students how to input distance and time, as well as the direction they wanted the body to move—whether forward, backward, or stationary. I also graphed these movements on the whiteboard for the students. By the end of this demonstration, the students knew exactly how to code on the platform and how to graph movements on a distance/time graph. Following this activity, the students took a break.” (4th December, 2023, Observation Field Note, Line Number: 34-41).

The second sub-theme, "coding and graphing," highlights the active involvement of the students in the coding task during the execution of the 3D simulation task on the CoSpacesEdu platform, followed by the graphing of the movements derived from the 3D simulation. In this stage of the lesson, the students collaborated on the 3D simulation task, with some reading instructions from the provided worksheet while others translated these instructions into executable codes on the platform. Following the task execution, the students graphed the simulated movements and engaged in calculations related to speed on the accompanying worksheet. This multifaceted activity not only encouraged collaborative learning but also served as an effective assessment strategy, evaluating the students' performance in executing the 3D simulation task. The researcher elaborated on this process as follows:

“The 3D simulation was opened and ready for use by the students on their laptops. Their task involved conducting a simulation using a worksheet given to them. In this task, the students wrote codes to make a body move through different distances at different times, working collaboratively. While some students read the instructions for the task, others executed the instructions in the form of codes on the platform. After the simulation, they graphed the movement on a distance/time graph and calculated the speed of the body on the provided worksheet.” (4th December, 2023, Observation Field Note, Line Number: 49-55).

The third sub-theme explores the visualization aid and the subsequent comprehension of the 3D simulation provided to the students. As per the researcher's observations, the students' remarkable proficiency in completing the 3D simulation task served as a clear indication of their understanding of the lesson. Furthermore, the researcher emphasized that the 3D simulation played a pivotal role in aiding the students' visualization and comprehension of diverse movements within 3D scenarios. This underscores the effectiveness of incorporating such interactive and visual tools to enhance the students' grasp of complex scientific concepts. The researcher elaborated on this process as follows:

“Upon inspecting the 3D simulation tasks on the students' laptops and the completed worksheets they presented, it was evident that they had done a marvellous job, completing the task perfectly. From my perspective, this is a great assurance that the technological tools

significantly contributed to their understanding of the topic. Furthermore, the 3D simulation proved highly beneficial, helping the students visualize and comprehend various movements in 3D scenarios. The students really enjoyed the task and completed it with enthusiasm, collaborating with their colleagues.” (4th December, 2023, Observation Field Note, Line Number: 56-62).

3.3.2.5. Assessment with technological tools

This theme underscores the technological tools utilized at the assessment stage of the lesson. As documented in the researcher's entry, Kahoot was employed for individual assessment, featuring 15 questions that comprehensively covered the entire topic. Notably, the students independently completed the assessment task using their mobile phones. The researcher highlighted the exceptional performance exhibited by the students, as reflected in the grades obtained from the Kahoot assessment. The researcher elaborated on this as follows:

“At the end of the lesson, at the assessment stage, I employed Kahoot as the technological tool to assess the students' understanding of the lesson. The Kahoot comprised fifteen questions I developed, covering the entire topic, with a particular emphasis on the various kinds of movements on the distance/time graph. Each student completed the Kahoot task individually on their smartphones. The students performed exceptionally well, as evidenced by the feedback from Kahoot.” (4th December, 2023, Observation Field Note, Line Number: 63-68).

3.3.2.6. Problems encountered and their solutions

This theme details the problems encountered during the implementation of the lesson and outlines the proactive approach taken to address these problems. According to the researcher's entry, the overall implementation proceeded smoothly, devoid of any reported problems or challenges. The researcher went on to emphasize the absence of problems, both on his part and among the students. The researcher succinctly captured this encounter as follows:

“In this implementation, everything unfolded as planned, and no problems or challenges were encountered as a result of the integrated technological tools. Furthermore, from my observations, I did not witness any students struggling with the technological tools or facing any challenges during the lesson. Similarly, no student reported any problems to me throughout the lesson.” (4th December, 2023, Observation Field Note, Line Number: 77-81).

The second sub-theme, "adaptations during the lesson," underscores the significance of logistical preparations during breaks to facilitate a seamless continuation

of the lesson. During these breaks, the researcher took measures to ensure the readiness of the students' phones and the CoSpacesEdu platform on the laptops. This proactive step aimed to prevent any unnecessary delays, ensuring that valuable time would not be spent addressing these technical aspects during the actual lesson time. The emphasis on efficient logistical preparation contributed to the overall smoothness and efficiency of the instructional process. The researcher documented this phase of the implementation as follows:

“During the ten-minute break, I seized the opportunity to retrieve the students' phones from the office for use in the upcoming Kahoot activity. Additionally, I double-checked to ensure that the CoSpacesEdu platform on the students' laptops was still active and running.” (4th December, 2023, Observation Field Note, Line Number: 42-44).

3.3.2.7. Reflection

This theme highlights the significance of gathering feedback and insights from the students to evaluate the effectiveness of the lesson. The first sub-theme delves into the instruments utilized by the researcher to collect data from the students, encompassing a questionnaire, students' reflections, and a focus group interview. Through the questionnaire and reflection, the students shared valuable feedback, addressing challenges faced and expressing their perspectives on the impact of technological tools. Furthermore, a focus group interview was conducted to delve deeper into the collective insights and experiences of the students, providing a comprehensive understanding of their perspectives throughout the lesson implementation. The researcher documented this phase of the implementation as follows:

“After the Kahoot task, I solicited feedback from the students regarding their experience in the lesson. Initially, they individually completed a three-question questionnaire addressing any challenges or problems encountered during the lesson involving technological tools and how these tools enhanced their understanding and enjoyment of the lesson. Subsequently, they wrote an exit ticket in the form of a reflection, sharing their views and experiences about the lesson. At 11:40 am, the students took a break for lunch. After the lunch break at 12:20 pm, I conducted a focus group interview with the entire class to delve deeper into their insights and gather collective feedback on the lesson.” (4th December, 2023, Observation Field Note, Line Number: 69-76).

3.3.3. Findings from the researcher's observation protocol

Table 23 presents the themes and sub-themes that emerged from the researcher's observation protocol during the third implementation.

Table 23. *Themes and sub-themes emerged from the researcher's observation protocol during the third implementation*

Themes	Sub-themes
1. Integration and Utilization of Technological Tools in Lesson Activities	Technological Tools Utilized Technological Tools Integration Phases Initial Activities Mid-Lesson Activities Concluding Activities
2. Students' Participation and Interaction with Technological Tools	Interactive Learning Experience Collaborative 3D Simulation Enthusiastic Kahoot Assessment High Engagement and Active Participation
3. Encountered Problems	No Problems Encountered
4. Resolution of Problems Encountered	
5. Impact of Technological Tools on the Classroom Environment	Seating Arrangement Change Enhanced Interaction and Support

3.3.3.1. Integration and utilization of technological tools in lesson activities

The researcher meticulously outlined the technological tools integrated into the lesson within the observation protocol as follows:

“Three technological tools were integrated into the lesson: an interactive video, a 3D simulation, and Kahoot.” (Observation Number 3, Date: 4th December, 2023).

The second sub-theme delves into the specific stages at which the technological tools were seamlessly integrated into the lesson. The researcher demonstrated adept use of these tools at various crucial phases, commencing from the beginning of the lesson, progressing through the middle phase, and culminating at the end of the lesson. The observation protocol provided comprehensive insights into these stages, offering a detailed account of how each technological tool was strategically employed to complement and enhance different aspects of the lesson.

“At the beginning of the lesson, the interactive video was presented on the smartboard for the students. In the middle of the lesson, the students carried out a 3D simulation task. At the end of the lesson, Kahoot was used to assess the students' understanding of the lesson.” (Observation Number 3, Date: 4th December, 2023).

At the beginning of the lesson, the researcher initiated the instructional process by presenting the Cambridge Lower Secondary Science Stage 8 software on the smartboard. This was followed by a question-and-answer session designed to assess the students'

relevant prior knowledge concerning the current science topic. Subsequently, the researcher strategically incorporated an interactive video to provide a concise and vivid introduction to the science topic. The interactive video served the dual purpose of aiding the students in describing movements on a graph and engaging in calculations related to speed. The researcher detailed these actions in the observation protocol as follows:

“At the beginning of the lesson, a question-answer session was conducted using the Cambridge Lower Secondary Science Stage 8 software displayed on the smartboard. Following this, the students watched an interactive video presented on the smartboard. The video featured pauses for the students to engage in calculations, and subsequently, it revealed the answers to the questions along with the processes involved in the calculations. A classroom discussion ensued, allowing the students to further explore and solidify their understanding.” (Observation Number 3, Date: 4th December, 2023).

In the middle of the lesson, the researcher seamlessly integrated a 3D simulation to further enrich the learning experience. At this stage, the researcher delivered a step-by-step demonstration, guiding the students on how to successfully execute the 3D simulation task. Additionally, detailed instructions were provided on graphing the movements derived from the task using a distance/time graph worksheet thoughtfully prepared by the researcher. This preparatory phase ensured that, before embarking on the 3D simulation task, the students were well-acquainted with the necessary skills and procedures, optimizing their engagement and comprehension during the execution of the 3D simulation. The researcher provided additional details on this integration in the observation protocol as follows:

“In the middle of the lesson, the students actively participated in a 3D simulation task. In this activity, they wrote a few lines of code to direct a virtual body through various distances within specified timeframes, following the instructions on the provided worksheet. Post-simulation, they graphed the movement on a distance/time graph on the worksheet and calculated the speed of the body they had graphed.” (Observation Number 3, Date: 4th December, 2023).

Finally, at the end of the lesson, marking the assessment phase, the researcher utilized Kahoot as a valuable tool to assess the students' individual understanding of the lesson. In this phase, the students independently completed the Kahoot task using their mobile phones. This assessment approach not only assessed the effectiveness of the lesson but also provided an interactive and engaging platform for the students to demonstrate their understanding. The researcher elaborated on this in the observation protocol as follows:

“At the end of the lesson, the students individually answered questions on Kahoot, serving as an assessment tool to evaluate their understanding of the entire lesson. The Kahoot consisted of fifteen questions, comprehensively covering the topics addressed throughout the lesson.” (Observation Number 3, Date: 4th December, 2023).

3.3.3.2. Students' participation and interaction with technological tools

The integration of diverse technological tools into the science lesson has elicited varied reactions from the students. These reactions have manifested in various interactions with the integrated technological tools, spanning from the beginning to the middle and finally at the end of the lesson. The nuanced interactions observed at different stages of the lesson have given rise to sub-themes that underscore the interactive learning experience, collaborative engagement during the 3D simulation, and enthusiastic participation in the Kahoot assessment. This multifaceted engagement highlights the impact and effectiveness of integrating technology to foster dynamic and participatory learning experiences for students.

The first sub-theme, "interactive learning experience," underscores the positive impact of the interactive video on the students' engagement and comprehension. The dynamic and participatory nature of the video not only fostered active participation but also prompted inquiries and lively discussions among the students. This interactive approach significantly contributed to a robust sense of understanding among the students by the end of the session. The researcher documented this interaction in the observation protocol as follows:

“The students enjoyed the interactive nature of the video and actively participated in the questions it presented. The interactive nature of the video also provided an opportunity for the students to inquire about the concepts they found challenging, sparking a lively and comprehensive discussion. By the end of the interactive video session, all the students expressed a strong sense of understanding of the concepts covered.” (Observation Number 3, Date: 4th December, 2023).

In the middle of the lesson, the students expressed a strong sense of accomplishment, emphasizing an enhanced understanding of the lesson. They particularly expressed the enjoyable and engaging aspects introduced through the 3D simulation task they actively participated in. This positive feedback from the students indicated that the integration of the 3D simulation not only facilitated learning but also added an enjoyable and engaging dimension to the educational experience, fostering a deeper comprehension

of the scientific concepts being taught. The researcher documented this interaction in the observation protocol as follows:

“In the middle of the lesson, the students worked collaboratively on a 3D simulation task using their laptops, writing a few lines of code. They conveyed a strong sense of accomplishment and emphasized that the task not only deepened their understanding of the lesson but also brought an enjoyable and engaging element to the learning experience.”
(Observation Number 3, Date: 4th December, 2023).

The third sub-theme highlights the positive and enthusiastic participation of the students during the Kahoot assessment at the end of the lesson, highlighting their active engagement and interest in this interactive form of assessment. Furthermore, the students expressed a keen interest in participating in more Kahoot activities, signalling a desire for continued engagement with this interactive and enjoyable assessment method.

“During the assessment phase at the end of the lesson, the students individually answered the questions on their smartphones with enthusiasm and attentiveness. Notably, the students expressed a desire to participate in more Kahoot activities, showcasing a keen interest in this interactive and engaging form of assessment.” (Observation Number 3, Date: 4th December, 2023).

Finally, the integration of various technological tools into the lesson consistently sparked heightened engagement and active participation from the students, maintaining a high level of involvement from the beginning to the end of the lesson. The students exhibited full attention and active involvement during key phases, including the presentation of the interactive video at the beginning, the collaborative execution of the 3D simulation and assessment task, and the discussions held throughout the session. The researcher attributed the students' comprehensive understanding of the lesson to their attentive and active participation throughout the lesson, emphasizing the positive impact of technology on sustained engagement and learning outcomes. The researcher provided further elaboration on this aspect as follows:

“The students demonstrated high engagement and active participation throughout the lesson. They dedicated their full attention to both the interactive video and the subsequent class discussion. The collaborative completion of the 3D simulation task and worksheet activities further showcased their involvement. During the Kahoot session, each student individually participated using their smartphones. Notably, the students consistently directed their attention towards the lesson content and the tasks being discussed and displayed. I would attribute their sustained high level of attention and active participation as key contributors to their understanding of the lesson.” (Observation Number 3, Date: 4th December, 2023).

3.3.3.3. Encountered problems

This theme, which delves into the problems encountered by both the researcher and the students during the lesson where various technological tools were integrated, reveals that, the implementation unfolded precisely as planned, and no problems were encountered. The researcher elaborated on this as follows:

“Throughout the lesson, no problems were encountered or observed in the classroom. The lesson unfolded precisely as planned, and there were no reported issues from the students regarding the integrated technological tools.” (Observation Number 3, Date: 4th December, 2023).

3.3.3.4. Resolution of problems encountered

This theme explores the resolution of problems encountered during the lesson. The researcher conveyed that, as no problems were encountered or observed throughout the lesson and no student reported any issues with the integrated technological tools, no specific actions were taken to resolve any challenges or problems. The absence of reported issues indicated the overall smooth implementation of the lesson without the need for corrective measures. The researcher elaborated on this as follows:

“Given that no problems were encountered or observed during the lesson and no student reported any issues with the integrated technological tools, no action was taken to resolve any challenges or problems. The smooth progression of the lesson indicated that the integration of the technological tools was successful and well-received by the students.” (Observation Number 3, Date: 4th December, 2023).

3.3.3.5. Impact of technological tools on the classroom environment

To ensure the smooth integration of technological tools into the science lesson, several adjustments were made in the classroom setting, leading to the development of two sub-themes: "Seating Arrangement Change" and "Enhanced Interaction and Support." The key adjustment involved transitioning from traditional rows to group seating, with the goal of cultivating a collaborative learning environment. This change not only facilitated interactive lessons but also contributed to enhanced classroom management, creating a positive impact on the overall learning experience. The researcher elaborated on this adjustment in the observation field note as follows:

“In response to the integration of technological tools into the lesson, the seating arrangement of the students was transformed from rows to groups. This change facilitated collaborative

learning, enabling the students to actively participate in the lessons and complete the tasks using technological tools collectively. This adjustment not only fostered a more interactive classroom environment but also streamlined classroom management. By directing attention and tasks toward group activities rather than individual tasks, it became more efficient to supervise and guide the students.” (Observation Number 3, Date: 4th December, 2023).

Moreover, the classroom adjustments had a positive impact on the dynamics among the students throughout the instructional process. The transition from traditional to group seating not only facilitated collaborative learning but also specifically enhanced interactions during the execution of the 3D simulation task. This change encouraged peer support, fostering a collaborative environment where the students actively engaged with each other, collectively solved problems, and successfully completed tasks within the group setting. The shift in seating arrangement played a crucial role in promoting teamwork and interactive learning experiences. The researcher elaborated on this in the observation field note as follows:

“Moreover, the collaborative nature of the classroom, enhanced by the use of technological tools, empowered the students to offer peer support. This was particularly evident during the completion of the 3D simulation tasks, where the students engaged in peer scaffolding, assisting each other in problem-solving and task completion. The structured classroom order and the utilization of technological tools, such as Kahoot, made it feasible to assess the individual students' understanding of the lesson.” (Observation Number 3, Date: 4th December, 2023).

3.3.4. Findings from the students' exit tickets

After the science lesson integrated with technological tools, the students were prompted to share their experiences through exit tickets. It is important to note that on this day, all the students were present. However, only Students 5 and 6 opted not to write their exit tickets about the lesson. The exit tickets written by the students at the end of the lesson are presented below.

Student 1, in her exit ticket, highlighted the impact of the integration of technology, including an interactive video, 3D simulation, and Kahoot. She expressed that the integrated technological tools played a crucial role in improving her understanding of the lesson, particularly in visualizing the science concept. Additionally, she expressed that the interactive video's dynamic engagement, the 3D simulation's hands-on coding experience, and the competitive thrill of Kahoot collectively contribute to an enjoyable learning experience for her. Finally, Student 1 characterized the integrated technological

tools as helpful in understanding the lesson, making the lesson fun, and improving her performance. Student 1's exit ticket is as follows:

"In today's lesson, we learned about describing movement using an interactive video, 3D simulation, and Kahoot. I think the use of technology helps me a lot with visualizing. It also makes the lesson more fun because we can interact, just like we did with the video, simulation, and Kahoot. We watched the video, paused it, and answered some questions. For the simulation, it was interesting because it was 3D. We coded, and then we put our results on a graph and answered questions. And in Kahoot, we solved questions and had to be fast, which I think made it fun. Overall, using technology in science lessons makes it fun and helps you understand better. This learning method also improved my performance." (Third Week's Exit Ticket of Student 1).

In her exit ticket, Student 2 characterized the science lesson, integrated with various technological tools, as enjoyable. Despite the smaller number of integrated tools compared to the previous lessons, she emphasized that the experience was equally fun. The integrated technological tools included an interactive video, 3D simulation, and Kahoot. Additionally, Student 2 elaborated on how these tools were utilized, mentioning collaborative completion of questions on the interactive video and 3D simulation, along with individual completion of the Kahoot assessment task. Expressing happiness for achieving first place in the Kahoot assessment, Student 2 expressed hope for more enjoyable lessons like this in the future. The exit ticket of Student 2 is as follows:

"Our science lesson was very nice. Even though we had shorter tools used in this lesson, it was equally fun as the previous lesson. This time we had an interactive video where we answered the questions. After that, we opened a 3D simulation on our laptop and worked on it together. My group and I coded and drew the graph. Finally, we played Kahoot again, but this time, everyone played alone. I got 1st place this time. I'm proud of myself, and I hope for more fun lessons like this." (Third Week's Exit Ticket of Student 2).

Student 3 characterized the entire science lesson, integrated with various technological tools, as very good. She went on to elaborate on the activities carried out throughout the lesson, spanning from the beginning to the middle and finally to the end. Student 3 highlighted that at the beginning of the lesson, they answered questions using the interactive video. In the middle of the lesson, they engaged in a 3D simulation activity, and at the end of the lesson, they participated in a Kahoot assessment. Expressing appreciation for the entire learning experience, Student 3 expressed a desire to participate in more Kahoot activities in the future. Here is the exit ticket of Student 3.

"Today's lesson was very good. In the beginning of the lesson, we watched a video about describing movement. While watching the video, we sometimes paused and answered the

questions. The next thing we did was observe 3D simulations. After that, we did Kahoot. I really liked it. I think we should do more Kahoot.” (Third Week’s Exit Ticket of Student 3).

Student 4 expressed that the integration of interactive video, 3D simulation, and Kahoot into the science lesson elevated the entire learning experience, making it truly enjoyable. He emphasized how these integrated technological tools not only enhanced the enjoyment of the lesson but also deepened his understanding of the science lesson. Student 4 expressed appreciation for the 3D simulation in particular, highlighting its role in facilitating comprehension. Intriguingly, he expressed a desire to incorporate 3D simulations into daily learning, underscoring their significance in his educational journey. Here is the exit ticket of Student 4.

“Today’s lesson was really fun because we used interactive video, 3D simulation, and Kahoot. I really enjoyed and understood the lesson because of these technologies. I liked the 3D simulation. I hope we should do it every day.” (Third Week’s Exit Ticket of Student 4).

Student 7 started her exit ticket by providing clarity on the science topic covered and the corresponding activity undertaken. She stated "describing movement" as the topic learned and detailed how they explored the graphical representation of movements on a distance/time graph. Furthermore, she expounded on the series of activities involving various technological tools carried out throughout the lesson, spanning from its commencement to the middle and concluding phases. She outlined the utilization of an interactive video at the lesson's outset, engaging in a 3D simulation during the middle segment, and participating in a Kahoot assessment towards the lesson's conclusion. Concluding her reflection, she conveyed immense appreciation for Kahoot, attributing its contribution to rendering the lesson interesting, enjoyable, and fun. This is what Student 7 wrote in her exit ticket:

“In this lesson, we learned about describing movement and how to draw a line graph. At first, we watched an interactive video. In the middle of the lesson, we did some 3D simulation, and finally, we played Kahoot. I liked to play Kahoot because it was interesting and fun. The lesson was enjoyable and fun.” (Third Week’s Exit Ticket of Student 7).

Student 8 initiated his exit ticket by describing the science lesson as highly enjoyable. Further, he provided detailed insights into the interactive video session at the beginning of the lesson, emphasizing the engaging questions that not only added to the fun but significantly aided his understanding of the lesson, particularly in calculations related to speed. Additionally, he expressed enthusiasm for the 3D activity conducted in the lesson's middle segment, underscoring its contribution to the overall enjoyment of the

learning experience. The reflection concluded with Student 8 expressing his delight in the Kahoot assessment undertaken at the lesson's end, further emphasizing the holistic enjoyment derived from the varied and interactive activities carried out throughout the science lesson. Student 8's exit ticket is presented below:

“Today’s lesson was very fun. We answered questions in the interactive video at the beginning of the lesson, which was fun and helped me understand the lesson, especially how to calculate speed. I also enjoyed the 3D simulation and Kahoot.”

3.3.5. Findings from the questionnaire

After the science lesson integrated with various technological tools, the researcher employed a questionnaire to solicit information from the students about their learning experience. The sections of the questionnaire served as a reference for the development of themes. The themes that emerged from the questionnaire are as follows:

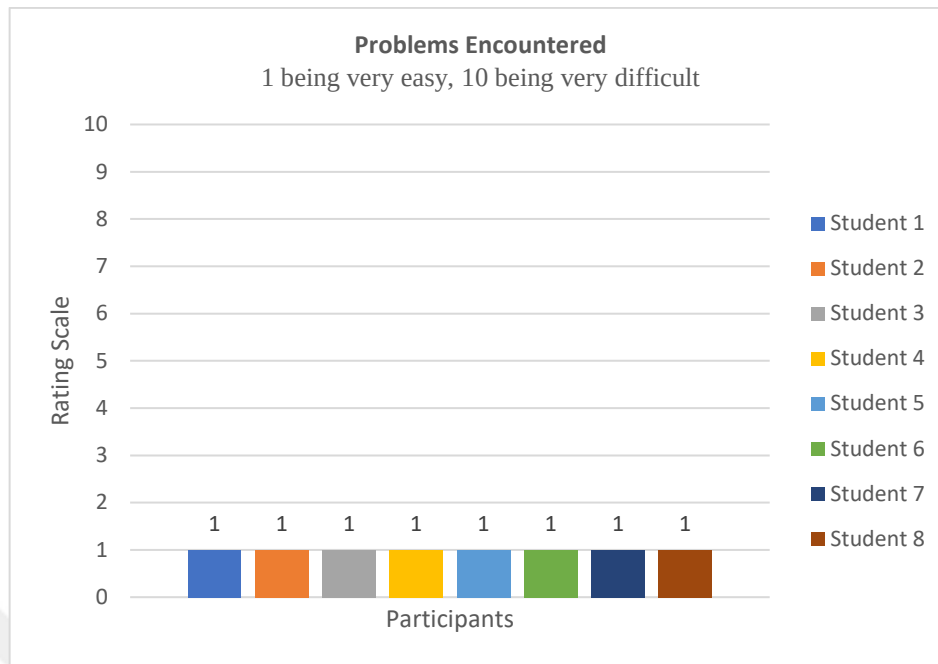
1. Problems Encountered
2. Technology’s Contribution to Understanding
3. Enjoyment of the Lesson with Technology

3.3.5.1. Problems encountered

Under this theme, the problems encountered by students during the science lesson integrated with technological tools were elaborated. Table 24 presents the rating scale for the problems encountered by students during the second implementation.

Table 24. *Rating scale on the problems encountered by the students during the third implementation*

Participants	Rating Scale									
	1	2	3	4	5	6	7	8	9	10
Student 1	✓									
Student 2	✓									
Student 3	✓									
Student 4	✓									
Student 5	✓									
Student 6	✓									
Student 7	✓									
Student 8	✓									



Graph 7. *Problems encountered by the students during the third implementation*

Table 24 and Graph 7 provide a comprehensive overview, demonstrating that all eight students actively participated in the lesson and subsequently completed the questionnaire. Both the tabular and graphical representations revealed uniform ratings from the students concerning the problems encountered during the lesson. Remarkably, all the students communicated that they did not face any challenges or difficulties during the lesson and consistently rated the questionnaire as 1 for the problems encountered. In the second section of the questionnaire, featuring an open-ended question prompting the students to "Describe any problems you encountered while having a science lesson integrated with technology," the students consistently expressed their views. The unanimity in the students' responses underscores a noteworthy consensus among the students, suggesting a positive and problem-free experience during the science lesson integrated with technology.

When prompted to articulate the problems faced during the science lesson integrated with various technological tools, the students responded succinctly, stating that they did not encounter any problems throughout the lesson. However, the response lacked specific details regarding their experience or potential obstacles faced. The students' comments are elaborated below:

Student 1: *"I didn't encounter any problems. It was fun and easy to understand."* (Answer of Student 1 for the First Question of the Third Week's Questionnaire).

Student 2: “I didn’t encounter any problems.” (Answer of Student 2 for the First Question of the Third Week’s Questionnaire).

Student 3: “I didn’t have any problems.” (Answer of Student 3 for the First Question of the Third Week’s Questionnaire).

Student 4: “No, I didn’t, because it worked very well.” (Answer of Student 4 for the First Question of the Third Week’s Questionnaire).

Student 5: “I didn’t face any problems.” (Answer of Student 5 for the First Question of the Third Week’s Questionnaire).

Student 6: “I didn’t encounter any problems.” (Answer of Student 6 for the First Question of the Third Week’s Questionnaire).

Student 7: “I didn’t face any problems.” (Answer of Student 7 for the First Question of the Third Week’s Questionnaire).

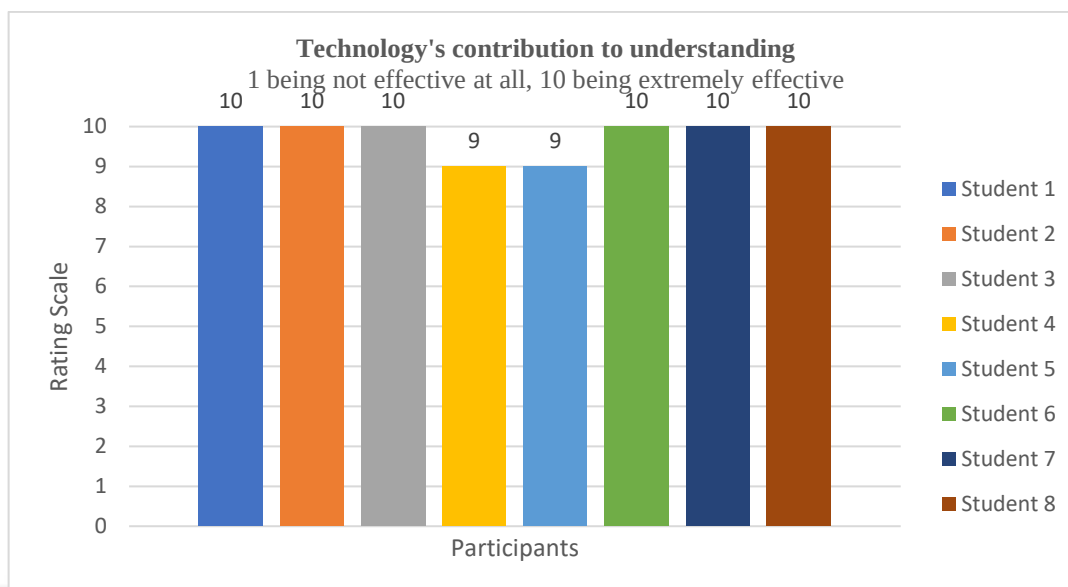
Student 8: “I didn’t face any problems.” (Answer of Student 8 for the First Question of the Third Week’s Questionnaire).

3.3.5.2. Technology’s contribution to understanding

This theme sheds light on the contributions of integrated technological tools to the students' understanding of the science lesson. Table 25 displays the rating scale (1 being not effective at all, 10 being extremely effective), illustrating technology's contribution to understanding.

Table 25. Rating scale on technology’s contribution to understanding during the third implementation

Participants	Rating Scale									
	1	2	3	4	5	6	7	8	9	10
Student 1										✓
Student 2										✓
Student 3										✓
Student 4									✓	
Student 5									✓	
Student 6										✓
Student 7										✓
Student 8										✓



Graph 8. *Technology's contribution to understanding during the third implementation*

Table 25 and Graph 8 clearly demonstrate that a majority of the students, specifically Students 1, 2, 3, 6, 7, and 8, provided a perfect rating of 10/10. This indicates that these students strongly believe that the technological tools integrated into the science lesson had a substantial impact on their understanding of the scientific concepts taught. Students 4 and 5 also recognized the high contribution of the integrated technological tools, assigning them a rating of 9. Remarkably, none of the students rated the contribution below 9, suggesting a unanimous agreement among the students that the integrated technological tools significantly enhanced their understanding of the science concepts taught. The collective high ratings affirm the positive impact of technology integration on students' learning experiences, underscoring the effectiveness of these tools in facilitating a deeper understanding of scientific concepts.

Moving on to the second section of the questionnaire, the students provided insightful comments, highlighting the positive impact of technological tools on their learning experience. The students' comments are presented below:

In her response, Student 1 explicitly expressed that the integrated technological tools in the science lesson contributed to her rapid understanding of the content. She specifically credited this enhanced understanding to the 3D simulation carried out during the lesson. This 3D simulation involved writing lines of code on the CoSpacesEdu platform, enabling the creation of a virtual scenario where a person could move at different speeds, including constant, stationary, and steeper speeds. Student 1

characterized the entire 3D simulation task as interesting. Student 1's comment is elaborated below:

"I could understand very fast, and especially the simulation we did today was very interesting. It was 3D, and we did coding as well." (Answer of Student 1 for the Second Question of the Third Week's Questionnaire).

Student 2 expressed that the integrated technological tools in the science lesson played a pivotal role in enhancing her understanding of the lesson. Student 2 concluded her reflection by characterizing the overall learning experience as enjoyable and fun. The following is Student 2's comment from the questionnaire:

"It helped me understand the graphs and the topic very well. And it was also very enjoyable and fun." (Answer of Student 2 for the Second Question of the Third Week's Questionnaire).

In her response, Student 3 characterized the entire science lesson, which integrated various technological tools, as very enjoyable. Student 3 further expressed appreciation for the incorporation of Kahoot, particularly during the assessment stage of the lesson. Notably, she emphasized the effectiveness of the entire lesson, attributing it to the repetition of materials used previously. It can be inferred from her response that she was alluding to the close relationship between the previous topic, speed, and the current topic, which involves describing movement. Furthermore, in the present topic, they engaged in various calculations related to speed on the distance/time graph. Here is what Student 3 wrote in the questionnaire:

"It was very nice; we worked in groups, and I also like Kahoot. It was effective because we repeated the materials we did before." (Answer of Student 3 for the Second Question of the Third Week's Questionnaire).

Student 4 succinctly shared that the integrated technological tools, such as the interactive video, 3D simulation, and Kahoot, were not only easy to use but also played a pivotal role in enhancing his understanding of the lesson. This is what Student 4 wrote in the questionnaire:

"It was understanding and easy to use." (Answer of Student 4 for the Second Question of the Third Week's Questionnaire).

Student 5 succinctly conveyed that the technological tools integrated into the science lesson were highly beneficial in aiding his understanding of the content. This is what Student 5 recorded in the questionnaire:

"Technology is helping to understand the lesson." (Answer of Student 5 for the Second Question of the Third Week's Questionnaire).

In his response, Student 6 conveyed that the integrated technological tools, including the interactive video, 3D simulation, and Kahoot, collectively contributed significantly to his understanding of the science lesson. Further elaborating, he highlighted the specific benefits of each tool. The 3D simulation, in particular, enhanced his understanding of the topic; the interactive video facilitated deeper learning; and Kahoot added an enjoyable element to his learning experience. This is what Student 6 recorded in the questionnaire:

“The simulation made me understand more of the topic in the lesson. The videos also helped me learn more. The Kahoot helped me, and in a really fun way.” (Answer of Student 6 for the Second Question of the Third Week’s Questionnaire).

Student 7 succinctly conveyed her perspective, stating that the integrated technological tools, including the interactive video, 3D simulation, and Kahoot, have played a helpful role in enhancing her understanding of the lesson. This acknowledgement underscores the positive impact of diverse technological tools on individual students' learning experiences. This is what Student 7 recorded in her questionnaire:

“In my opinion, technology helped me understand the lesson, such as simulation, video, and Kahoot.” (Answer of Student 7 for the Second Question of the Third Week’s Questionnaire).

Student 8 affirmed that the integration of technological tools, specifically interactive video, 3D simulation, and Kahoot, has significantly contributed to his understanding of the science lesson. This is what Student 8 recorded in the questionnaire:

“I understand the lesson very well because we used interactive video, 3D simulation, and Kahoot, which made me understand it very well.” (Answer of Student 8 for the Second Question of the Third Week’s Questionnaire).

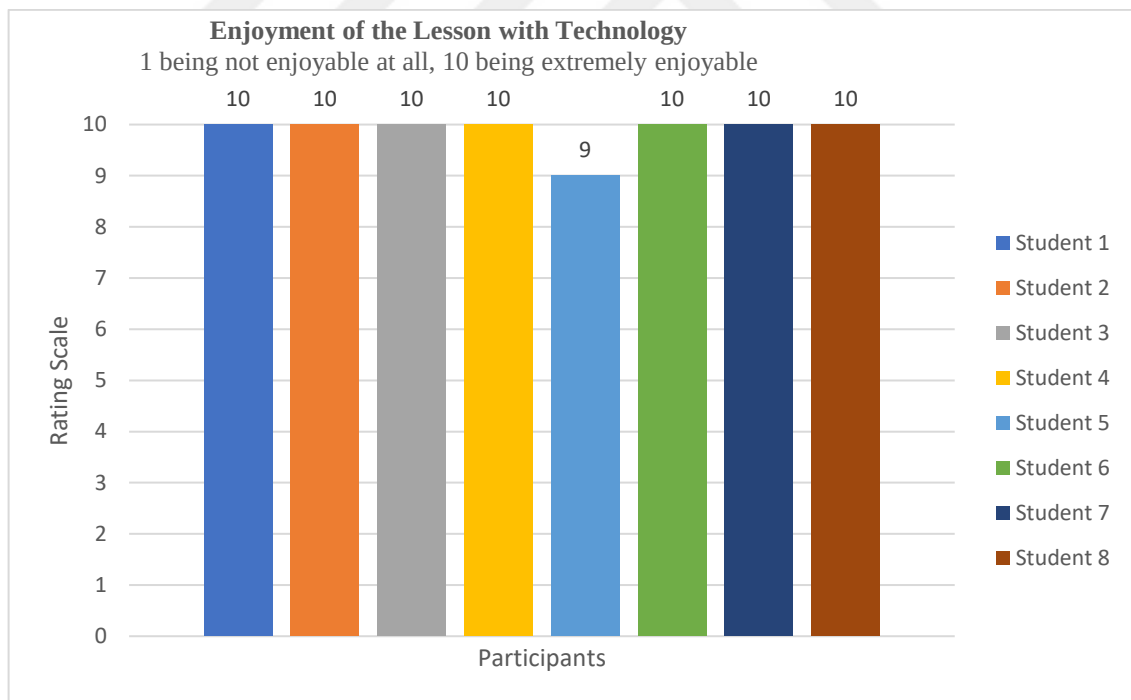
All the students unanimously affirmed that the integration of technological tools, including the interactive video, 3D simulation, and Kahoot in the science lesson, profoundly and positively contributed to their understanding. Their feedback consistently emphasized the impact of these tools on enriching their comprehension. Many students credited the interactive video for its dynamic question-and-answer format, pausing for individual responses and subsequently guiding them through solutions. Furthermore, a majority highlighted the 3D simulation's interactive nature, integrating real-world contexts to create an immersive learning environment. Several students also noted the enjoyable aspect of the lesson, particularly the Kahoot used at the assessment stage, as a crucial factor in deepening their understanding.

3.3.5.3. Enjoyment of the lesson with technology

This theme underscores how the integrated technological tools made the lesson enjoyable for the students. Table 26 presents the rating scale, depicting the level of enjoyment of the science lesson with technology.

Table 26. Rating scale on the enjoyment of the lesson with technology during the third implementation

Participants	Rating Scale									
	1	2	3	4	5	6	7	8	9	10
Student 1										✓
Student 2										✓
Student 3										✓
Student 4										✓
Student 5									✓	
Student 6										✓
Student 7										✓
Student 8										✓



Graph 9. Enjoyment of the lesson with technology during the third implementation

An analysis of both Table 26 and Graph 9 reveals a noteworthy pattern in the students' ratings regarding the impact of integrated technological tools on their enjoyment of the science lesson. All the students, except Student 5, gave a perfect rating of 10,

signifying a significant enhancement in their overall lesson enjoyment. Student 5 closely trailed with a commendable rating of 9. This consistent trend, devoid of any ratings below 9, underscores the pervasive positive influence of technological tools integrated into the science lesson. The majority of the students evidently perceived these tools as pivotal in heightening the enjoyment of their learning experience. The collectively high ratings robustly affirm that the integration of technological tools undeniably contributed to an enriched and enjoyable science lesson experience for all the participating students.

The second section of the questionnaire introduced an open-ended question, prompting the students to offer insights into how the integrated technological tools contributed to their enjoyment of the lesson. The question asked was, "In your opinion, how does the integration of technology in science lessons enhance the overall enjoyment of the learning experience?" The students' responses, representing a diverse range of perspectives, are presented below based on their comments from the questionnaire.

In her response regarding how integrated technological tools contributed to her enjoyment of the science lesson, Student 1 articulated that the tools not only facilitated a better understanding but also added a fun dimension to the learning experience, particularly through the collaborative 3D simulation task with her peers. Furthermore, she singled out Kahoot, the tool employed for the assessment task, as her favorite, attributing it to being the most effective in enhancing her understanding of the lesson. Student 1 captured this in the questionnaire as follows:

"It helped me understand better, and we also did the simulation with my classmates, which made it more fun. But Kahoot was my favorite; it was fun, and it made me understand the best." (Answer of Student 1 for the Third Question of the Third Week's Questionnaire).

In her response, Student 2 did not explicitly state how the integrated technological tools contributed to her enjoyment of the lesson. However, she highlighted that, in her opinion, these tools have the capability to clarify any confusion she may have and provide effective examples that explain the lesson thoroughly. It can be inferred from Student 2's response that the ability of technological tools to alleviate confusion and offer clear examples significantly contributed to her enjoyment of the lesson. Student 2's questionnaire entry is as follows:

"In my opinion, it can clear any confusion you have and provide good examples that explain very well." (Answer of Student 2 for the Third Question of the Third Week's Questionnaire).

Student 3 offered a clear and enthusiastic perspective on how the integrated technological tools transformed the science lesson into an immensely enjoyable

experience. In particular, she highlighted the pivotal role of Kahoot during the assessment stage, underscoring how this interactive tool added an element of excitement and engagement to the lesson. Additionally, she expressed a strong appreciation for the 3D simulation, emphasizing how it enriched the learning process and contributed to the overall enjoyment of the lesson. This is what Student 3 recorded in her questionnaire:

"It is very enjoyable; we did Kahoot. I really liked it. I also liked the simulation." (Answer of Student 3 for the Third Question of the Third Week's Questionnaire).

Student 4 characterized the science lesson, integrated with various technological tools, as a fun experience. Expressing a positive opinion, he recommended that such lessons, integrated with various technological tools, should be repeated. This is what he wrote in the questionnaire:

"It was really fun, and in my opinion, we should do it again." (Answer of Student 4 for the Third Question of the Third Week's Questionnaire).

Student 5 attributed the enjoyable nature of the lesson to the utilization of Kahoot during the assessment stage. This is what student 5 wrote in the questionnaire:

"Yes, the lesson was enjoyable because we played Kahoot." (Answer of Student 5 for the Third Question of the Third Week's Questionnaire).

Student 6 concisely conveyed that the technological tools integrated into the science lesson played a pivotal role in contributing to the genuine enjoyment and fun of the lesson. This is what student 6 wrote in the questionnaire:

"It helped us understand in a really enjoyable and fun way." (Answer of Student 6 for the Third Question of the Third Week's Questionnaire).

Student 7 succinctly expressed that among the technological tools integrated into the science lesson, it was Kahoot that significantly contributed to her enjoyment of the science lesson. Student 7's questionnaire entry is as follows:

"I enjoyed because of Kahoot." (Answer of Student 7 for the Third Question of the Third Week's Questionnaire).

Student 8 succinctly conveyed his opinion that among the technological tools integrated into the science lesson, it was Kahoot that made the lesson most enjoyable for him. Student 8's questionnaire entry is as follows:

"In my opinion, today's lesson was very enjoyable because of Kahoot." (Answer of Student 8 for the Third Question of the Third Week's Questionnaire).

The feedback gathered from the students consistently conveys a positive sentiment regarding how the integration of technological tools significantly enhanced their overall enjoyment of the science lessons. Notably, every student unequivocally acknowledged

the noteworthy contribution of these technological tools to the enjoyable nature of the lessons. A common thread in the students' responses was the positive impact of the 3D simulation on elevating their enjoyment and the notable role of Kahoot during the assessment stage. Moreover, many students highlighted that the integration of technological tools not only heightened the enjoyment of the lessons but also added an element of fun to the entire learning experience.

3.3.6. Findings from the semi-structured focus group interview

Following the completion of the science lesson, integrated with diverse technological tools, the students' feedback on their experience was solicited through a semi-structured focused group interview. In order to make sense of the gathered data, a thematic analysis approach was employed. Table 27 outlines the emergent themes and sub-themes from the semi-structured interview, providing a foundation for in-depth analysis.

Table 27. Themes and sub-themes emerged from the semi-structured interview during the third implementation

Themes	Sub-Themes
1. Lesson Content	Describing Movement
2. Utilization of Technological Tools	Types of Technological Tools Used How Technological Tools Were Used Stages of Tool Usage
3. Impact of Technological Tools	Interactive Learning and Engagement Enhanced Conceptual Understanding Positive Impact on Motivation and Enjoyment Facilitation of Collaborative Learning
4. Feelings Toward Technology	Positive Emotional Engagement Enhanced Focus and Collaboration
5. Problems Encountered	Absence of Problems
6. Students' Views on the Impact of Technology Integration in Science	Enhanced Enjoyment and Interest Improved Understanding and Accessibility Desire for More Technological Integration Improved Understanding and Visualization Focus and Engagement
7. Student Inquiries and Additional Comments	Desire for More Kahoot Interest in 3D Simulations with Coding Active Student Participation

3.3.6.1. Lesson content

This theme illuminates the subject addressed during the science lesson, which incorporated a variety of technological tools. The associated sub-theme offers a more

detailed perspective on the particular topic covered throughout the entire lesson, specifically focusing on the concept of describing movement. This deeper insight provides a clearer understanding of the core content addressed during the lesson, emphasizing the integration of technology in teaching this specific scientific concept.

TEACHER: *In our interview today, we are going to talk about the technological tools we used in our lessons. So, I have a couple of questions for you. Let's begin with the first question. What did you learn in class today? Student 1?*

Student 1: *We learned about describing movement.*

3.3.6.2. Utilization of technological tools

This theme highlights the pivotal role played by the various technological tools integrated into the science lesson. The corresponding sub-themes provide valuable insights into the specific types of technological tools seamlessly integrated into the lesson, including an interactive video, 3D simulation, and Kahoot. The second sub-theme delves into how these technological tools were utilized in the lesson, as elaborated by the students. Finally, the third sub-theme explores the temporal organization of these technological tools, categorizing their usage at distinct stages—beginning, middle, and end. This comprehensive view offers a detailed understanding of the integration of technology throughout the session, showcasing its varied applications. The interview dynamics between the teacher and students unfolded as follows:

TEACHER: *In this lesson, were technological tools used?*

Student 2: *Yeah, there were technological tools used.*

TEACHER: *Okay. Student 6, can you list the technological tools we used in the lesson?*

Student 6: *Interactive video, 3D simulation, and Kahoot.*

TEACHER: *Thank you very much.*

Student 6: *You're welcome.*

TEACHER: *So, the next question is: how were these technological tools used? So, let's begin with the first technological tool, which was the interactive video. Student 1, how was the interactive video used?*

Student 1: *So, we first opened the video, and when they asked us a question, we paused the video, and then we solved the questions, and then we checked their answers from the video.*

TEACHER: *Thank you very much. Okay, let's look at the second technological tool, which was the 3D simulation. How was the 3D simulation used? Student 1, can you explain how the 3D simulation was used in the lesson?*

Student 1: *Sure, we first did coding, which, uh, then after coding, we plotted the results on our graphs with a paper graph.*

TEACHER: *Okay. Did you do it individually or as a group work?*

Student 1: *As a group work.*

TEACHER: *As a group work! Okay, thank you. The last technological tool we used was Kahoot. Student 7, what can you tell me about how we use the Kahoot?*

Student 7: *Uh, first, we like, individually take our phones, and there were some questions, and we needed to be fast, and we solved the questions.*

TEACHER: *Okay, thank you very much. So, the next question is, uh, at which part of the lesson did we use these technological tools? So, Student 8, in the beginning of the lesson, what technological tool did we use?*

Student 8: *We used interactive video.*

TEACHER: *Thank you very much. Student 4. In the middle of the lesson, what technological tool did we use?*

Student 4: *3D simulations.*

TEACHER: *Thank you. And Student 6, at the end of the lesson, what technological tool did we use?*

Student 6: *We played Kahoot.*

3.3.6.3. Impact of technological tools

This theme clarifies the students' perspectives on the impact of the technological tools integrated into the science lesson on their understanding. It centers around the notion that the integration of these tools positively enriched the overall learning experience for the students. The sub-themes underscore the interactive nature of learning, the influence on conceptual understanding, the positive impact on motivation and enjoyment, and the promotion of collaborative learning through the use of technological tools. This multifaceted approach provides a comprehensive view of how the integration of technology has positively shaped various aspects of the students' learning experience in the science lesson. The interaction between the teacher and the students on the impact of technology on their learning is as follows:

TEACHER: *So, for the next question, let's talk about the impact the technological tools had on our understanding of the course. So, what impact did the technological tools have on your understanding of the course? Let's begin with Student 3.*

Student 3: *So, it was more interesting that way than the usual lesson, and I think I learned more in that lesson. Probably.*

TEACHER: *Okay. Did the technological tools help you understand the lesson better?*

Student 3: *Yes.*

TEACHER: *In what way?*

Student 3: *Well, it was just more interesting, and we watched videos and used animation, and it made me understand.*

TEACHER: Did you say animation?

Student 3: Yes, like 3D, oh, 3D simulation.

TEACHER: Okay, thank you very much. So, Student 2, what impact did the technological tools used in the course have on your understanding of the course?

Student 2: I think it helped me to understand how the graphs work better and how we can, um, understand the line, the speed, and the distance, and I think it was very clear.

TEACHER: Okay. Thank you very much. Student 8?

Student 8: Uh, it helped me visualize it more and, like, helped me understand it way better.

TEACHER: Thank you very much. Student 1, what impact did the technological tools used in the lesson have on your understanding of the lesson?

Student 1: It made the lesson more fun and interesting, and it made everything easier to understand because I could see it and how it was done.

TEACHER: Thank you. Student 5, the question is, what impact did the technological tools used in the lesson have on your understanding of the lesson?

Student 5: It helped me to understand the lesson because we played games and there's some, uh, simulations, and it's helping to understand the lesson.

TEACHER: Thank you very much. Student 7, how did these technological tools help you understand the lesson?

Student 7: Uh, first we watched the video; it was like, uh, I learned more about this kind of movement, and at the end of the lesson, we do some Kahoot. It was fun and enjoyable.

TEACHER: Thank you very much. Student 4, how did these technological tools help you understand the lesson?

Student 4: It made me understand very well, and it was also fun, and it's a fun way to learn with other people.

TEACHER: Thank you very much. Student 6, what impact did the technological tools used in the course have on your understanding of the course?

Student 6: So basically, it helped us learn even better, and it made us focus, in my opinion, because, like, it's just way more fun.

3.3.6.4. Feelings toward technology

This theme explores the students' overwhelmingly positive emotions towards the technological tools integrated into science lessons. The sub-themes highlight the transformative impact of these tools, evoking happiness, enjoyment, and excitement, creating a more pleasant classroom environment. Additionally, the tools enhanced focus and collaboration, leading to concentrated learning and a sense of camaraderie among the students. Overall, the integration of technology positively shapes both academic understanding and emotional engagement in the classroom. The interaction between the students and the teacher unfolded as follows:

TEACHER: Student 2, how did the use of technological tools in class make you feel?

Student 2: Probably very happy, and I think more focused on the lesson.

TEACHER: Why did you feel happy?

Student 2: Because it was entertaining and enjoyable.

TEACHER: Thank you very much. Student 1, how did the use of technological tools and equipment in class make you feel?

Student 1: I was also happy because, if there was a question I didn't understand, I could just do it with my friends and I would understand better. So overall, it was good.

TEACHER: Thank you very much. Student 5, how did the use of technological tools in class make you feel?

Student 5: It feels happy because, uh, we did some <inaudible>, we did some questions, and it feels happy.

TEACHER: Thank you very much. Student 7, what about you?

Student 7: Um, I was happy and focused more.

TEACHER: Okay, thank you very much. Student 3, how did the use of technological tools in class make you feel?

Student 3: Uh, it was more interesting and enjoyable than it usually is, and a lot more.

TEACHER: Thank you very much. Student 4, how did the use of technological tools and equipment in class make you feel?

Student 4: It made me feel great.

TEACHER: Why did it make you feel great?

Student 4: Because it was fun. And we get to play Kahoot.

TEACHER: Thank you very much. Student 6, how did the use of technological tools in class make you feel?

Student 6: It made me feel very happy, energetic, and fun.

TEACHER: Thank you very much. Student 8, what about you?

Student 8: Uh, it made me feel very happy, and it was a very fun way of learning, in my opinion.

3.3.6.5. Problems encountered

This theme focuses on the problems the students encountered during the science lesson integrated with various technological tools. It emphasizes the seamless integration of these tools in the lesson, as the students uniformly reported a lack of encountered problems. All the students expressed in unison that they did not face any technical problems or difficulties while using the technological tools throughout the lesson. The absence of problems during the lesson significantly contributed to a smooth learning experience for all the students, highlighting the effectiveness of the integration process.

The interaction between the students and the teacher regarding the problems encountered during the lesson unfolded as follows:

TEACHER: *The next question is, Student 2, have you encountered any problems while using technological tools and equipment in the lesson?*

Student 2: *No, I haven't encountered any problems.*

TEACHER: *Everything went well with you?*

Student 2: *Yes.*

TEACHER: *Thank you very much, Student 2. What about you, Student 1?*

Student 1: *Same with me. I didn't face any problems. The lesson was great.*

TEACHER: *Thank you very much. Student 5, did you face any problems while using the technological tools in the lesson?*

Student 5: *No, I didn't face any problems.*

TEACHER: *Thank you very much. Student 7, what about you?*

Student 7: *I didn't face any problems.*

TEACHER: *Thank you very much. Student 3?*

Student 3: *No, I didn't have any problems.*

TEACHER: *Thank you. Student 4, did you face any problems?*

Student 4: *No*

TEACHER: *Thank you. Student 6, what about you?*

ISMAIL: *Um, no, I did not. I did not face any problems. Every technology was great.*

TEACHER: *Thank you very much. Student 8, what about you?*

Student 8: *Uh, same as everyone. I didn't face any problems.*

3.3.6.6. Students' views on the impact of technology integration in science

This theme highlights the impact of integrated technological tools on the students' grades and overall performance in the science lesson. It centers around the perceived positive influence of integrating technological tools in the learning process, particularly in terms of academic performance. The students expressed their belief that the use of these tools has contributed to improvements in their grades and overall performance. This acknowledgement suggests a positive correlation between the integration of technology and academic success, reinforcing the students' perception of the tools as beneficial to their educational outcomes. The interaction between the teacher and the students on how the integrated technological tools impacted their grades and performance in the science lesson unfolded as follows:

TEACHER: *Student 2, has there been any change in your grades or performance since you started using technological tools and equipment in the lesson?*

Student 2: *I think yes, it probably improved a lot.*

TEACHER: Okay. Uh, Student 1, what about you? Has there been any change in your grades or performance?

Student 1: I think my performance improved because I could clearly see what was going on, and it helped me visualize better.

TEACHER: Thank you very much. Student 1, what about you?

Student 7: I think my performance improved, and I can answer the questions well.

TEACHER: Thank you very much. Student 3, what can you say about the change in your grade and performance as a result of the technological tools?

Student 3: Well, I think I memorized how to do different calculations, and I think my grade improved.

TEACHER: So, your grade—did it improve because of the memorization or because of the technological tools?

Student 3: Because of the technological tools. Yes, because of the technological tools.

TEACHER: Okay. Which technological tool exactly?

Student 3: Uh, Kahoot.

TEACHER: Okay, thank you. Uh, Student 4, what about you? Has there been any change in your grade or performance since you started using technological tools in the lesson?

Student 4: I think so, yes, because it helped me improve in my grade.

TEACHER: Thank you very much. Uh, Student 6, what about you?

Student 6: Well, I guess, um, I think if we keep continuing and if I keep focusing, there would definitely be improvement in my grades and my performance.

TEACHER: So, with the technological tools we used, now or previously, did they help you get good grades and perform better in your lessons?

Student 6: The most technological tool which is Kahoot, and I focus more on Kahoot.

TEACHER: Okay. Student 8, what about you?

Student 8: Uh, I think it helped me improve my math because we do a lot of calculations, and this helps me, uh, be better at math.

Additionally, the students expressed diverse views and perceptions regarding the integration of technological tools in the science teaching and learning process. It mirrors the students' positive opinions and enthusiasm toward the integration of technological tools in the science lessons. The interaction between the teacher and the students regarding their general views on integrating technological tools into the science lesson is presented as follows:

TEACHER: What do you think about the use of technological tools in science lessons?

Student 2: I think it's really nice and enjoyable, and we should have a lot more of it.

TEACHER: Student 1, what about you?

Student 1: I think it makes the lesson more enjoyable and easier to understand.

TEACHER: Student 5, what do you think about the use of technological tools in science lessons?

Student 5: It is good. We need to do all the lessons.

TEACHER: Thank you very much. Student 7, what about you?

Student 7: It was interesting, and I said we need to do more Kahoot.

TEACHER: Thank you very much. Uh, Student 3, what do you think?

Student 3: It was more interesting and enjoyable, and we should do more Kahoot.

TEACHER: Thank you very much. Student 4, what about you?

Student 4: It was really good because we got to play Kahoot.

TEACHER: Thank you very much. Student 6?

Student 6: The use of technology? I guess Kahoot helped us; in my opinion, it helped us learn the most because it was fun.

TEACHER: Okay, and Student 8, what do you think about the use of technological tools in science lessons?

Student 8: I think, uh, it's very fun, and uh, mostly Kahoot made me learn more.

3.3.6.7. Student inquiries and additional comments

This theme underscores occasions during the interview where the students made inquiries and requests concerning the integrated technological tools in the science lesson. It highlights the students' active engagement in the learning process, expressing their preferences for specific interactive tools and making suggestions for future lessons. The sub-themes underscore the students' enthusiasm for interactive learning tools, with a strong preference for activities like Kahoot and a desire for more hands-on experiences, such as 3D simulations involving coding. This active participation and expression of preferences indicated a high level of student involvement in shaping their learning experiences and a keen interest in the incorporation of specific technological tools that enhance their engagement and understanding. The interaction that ensued between the teacher and the students is as follows:

TEACHER: Thank you very much. I think that's the end of the question. Is there any question from you or any contribution? Yes, Student 3?

Student 3: Could we please do more Kahoot?

TEACHER: Yeah, we will do more Kahoot in our next lessons. Anyone, Student 6?

Student 6: Kahoot, I want more Kahoot, please.

TEACHER: You want more Kahoot! Thank you very much. Anyone?

Student 4: Me!

TEACHER: Okay, Student 4.

Student 4: I guess we should do more Kahoot.

TEACHER: *Thank you very much. Any other? Yes, Student 1?*

Student 1: *Uh, can we have, like, more 3D simulations that include coding? I think it was great and helped me understand.*

TEACHER: *Thank you very much. Now that's the end of the interview. Thank you all for your contributions.*

ALL STUDENTS: *You're welcome.*

3.3.7. Findings from researcher's post-implementation reflection journal

After the science lesson integrated with technological tools, the researcher collected various forms of data from both himself and the students to assess the lesson and gain insights into its effectiveness. Subsequent to the data collection, the researcher composed a post-implementation reflection journal, outlining his perspective on the lesson's execution and outcomes. The data from the researcher's post-implementation reflection journal were categorized into themes and analyzed descriptively. This reflective process allowed the researcher to critically evaluate the lesson's success, identify areas for improvement, and gain a deeper understanding of the impact of technological tools on the learning experience. Here are the themes that emerged from the researcher's post-implementation reflection journal:

1. Optimal Impact of Integrated Technological Tools
2. Engaging Technological Tools for Active Learning
3. Positive Student Performance and Feedback
4. Pre-emptive Navigation of Technological Challenges
5. Clarification of Feedback Accuracy

3.3.7.1. Optimal impact of integrated technological tools

Under this theme, the researcher emphasized the successful integration of various technological tools into the science lesson, including an interactive video, 3D simulation, and Kahoot. This integration resulted in a positive impact on the students' understanding and enjoyment. The researcher also underscored the effectiveness and sufficiency of a thoughtfully selected set of tools in achieving instructional objectives, highlighting the notion of quality over quantity in the integration of technological tools. This is what the researcher documented in the post-implementation reflection journal.

"I hope you are doing well. I am doing well myself and am quite pleased with the morning lesson I had with my students. The lesson proceeded smoothly, and I was genuinely impressed

by the positive impact that the integrated technological tools had on their understanding and enjoyment. I incorporated an interactive video, a 3D simulation, and Kahoot into the lesson. Unlike previous occasions, I didn't use a plethora of tools this time, as the ones integrated proved to be sufficient in aiding the achievement of the instructional objectives.” (Ankara, 4th December, 2023, Line Number: 1-6).

3.3.7.2. Engaging technological tools for active learning

This theme highlights the integration of an interactive video, 3D simulation, and Kahoot throughout the lesson. According to the researcher’s post-implementation reflection journal entry, at the beginning of the lesson, an interactive video focusing on distance/time graphs and movements was integrated into the science lesson. This actively engaged the students by providing them with opportunities to carry out various calculations involving speed. In the middle of the lesson, a 3D simulation with coding was integrated, effectively illustrating different types of speed. The 3D simulation task not only showcased the students’ enthusiasm and appreciation but also highlighted their remarkable cooperation. At the end of the lesson, the implementation of Kahoot for individual assessment proved to be the most enjoyable, fostering eagerness and active participation, ultimately affirming the successful achievement of the lesson objectives. This theme emphasized the pivotal role of these technological tools in promoting active learning experiences across various phases of the lesson. The researcher recorded this as follows:

“At the outset of the lesson, I presented an interactive video to the students, focusing on distance/time graphs and describing movements. The interactive nature of the video significantly contributed to engaging the students in the lesson. The video incorporated pauses, allowing the students to perform calculations actively. Subsequently, the video revealed the answers and elucidated the procedures involved in the calculations. This multimedia approach provided me with an opportunity to further explain certain concepts to the students. The experience was highly beneficial, with the students not only enjoying the lesson but also participating actively in the discussions.

In the middle of the lesson, the students engaged in a 3D simulation where they performed coding to make a body move across various distances within different time frames. The 3D simulation proved to be highly effective in illustrating different types of speed to the students. Guided by the provided worksheet, the students explored various scenarios in the 3D simulation, and they executed the task commendably. Their positive reactions were evident, as they expressed enthusiasm and genuine appreciation for the 3D simulation. What stood out was the remarkable teamwork and mutual support displayed among the students during

the task. I am genuinely pleased with their reaction and the overall success of the 3D simulation.

At the end of the lesson, I employed Kahoot to assess the individual understanding of the students regarding the lesson. Each student completed the Kahoot quiz independently using their smartphones. From my observation, this turned out to be the most enjoyable segment of the lesson for the students. Their eagerness and active participation in the Kahoot were truly heart-warming. Moreover, they performed exceptionally well in the quiz. This success assured me that the lesson objectives and the purpose behind integrating these technological tools were effectively achieved. Interestingly, the students expressed a desire to engage in more Kahoot activities, although time constraints prevented us from doing so due to other scheduled activities.” (Ankara, 4th December, 2023, Line Number: 7-31).

3.3.7.3. Positive student performance and feedback

This theme delves into the exceptionally positive response from the students, as gathered from various sources such as questionnaires, exit ticket reflections, and post-lesson interviews. The unanimous satisfaction and enjoyment expressed by the students underscored the success of integrating technological tools, particularly Kahoot and the 3D simulation. Additionally, the researcher noted the clear and strong desire among the students for the continued use of these tools in future science lessons, indicating a marked improvement and positive shift compared to previous implementations. This overwhelmingly positive students' feedback reaffirmed the effectiveness and desirability of integrating these technological tools into the science learning experience. The researcher documented this as follows:

“Following the implementation, the students completed a three-question questionnaire that utilized a rating scale to assess the challenges and problems, enhancement of understanding, and increased enjoyment resulting from the integrated technological tools. With only eight participating students, the feedback received was overwhelmingly positive, marking a unique and positive response compared to the previous implementations.

Regarding the challenges posed by the integrated tools, on a scale of 1–10 (where 1 denotes very easy and 10 denotes very difficult), all eight students selected 1, indicating that they found the technologies very easy, encountering no problems or challenges. In terms of the effectiveness of technology's contribution to understanding (on a scale of 1–10, where 1 denotes not very effective at all and 10 denotes extremely effective), six students selected 10, and two students chose 9, underscoring a high level of perceived effectiveness in aiding their understanding. Lastly, concerning enjoyment (on a scale of 1–10, where 1 denotes not enjoyable at all and 10 denotes extremely enjoyable), all but one student selected 10, with the remaining students choosing 9. This comprehensive positive feedback emphasizes a

strong sense of enjoyment and satisfaction among the students, reflecting the success of the integrated technological tools in the lesson.

The exit ticket in the form of reflection written by the students and the interview conducted with the students after the lesson also revealed important insights from the students. The students expressed that they really enjoyed the lesson integrated with technological tools, and we should continue with all our science lessons like that. The students showed much affinity to all the tools; however, they really liked Kahoot and the 3D simulation.” (Ankara, 4th December, 2023, Line Number: 32-52).

3.3.7.4. Pre-emptive navigation of technological challenges

This theme underscores the proactive approach taken by the researcher to navigate the challenges associated with technological tools. The researcher acknowledged that while the actual implementation was smooth without any issues, a challenge was encountered in selecting the most suitable technological tools due to the nature of the science topic. However, the assistance and support from the validity committee played a crucial role in identifying the most suitable technological tools for the science lesson. This proactive and collaborative approach was adopted to prevent potential challenges that the wrong technological tools could pose during the lesson, reflecting the researcher's commitment to ensuring a seamless and effective integration of technology. The researcher documented this as follows:

“Regarding the problems encountered with the technological tools, I must note that I did not face any issues during the actual implementation of the tools. However, there were some challenges both before and after the implementation. Before the implementation, I encountered difficulty in selecting the appropriate technological tools due to the nature of the topic. The topic itself played a crucial role in determining which tools would be most effective. Fortunately, I am grateful for the assistance and support provided by my validity committee members, who offered valuable recommendations for selecting the best and most effective technological tools for the lesson.” (Ankara, 4th December, 2023, Line Number: 53-60).

3.3.7.5. Clarification of feedback accuracy

This theme underscores the significance of clarity in feedback responses, as observed during the post-implementation questionnaire. The researcher elaborates on unintentional errors made by the students in rating perceived problems encountered in the questionnaire. The importance of clear communication and guidance in the feedback process was highlighted, as the students corrected their responses when made aware of

the misunderstanding. This theme emphasized the need for precision in collecting accurate feedback to ensure a more reliable assessment of the impact of technological tools. Clear communication channels and guidance are crucial to obtaining insightful and accurate feedback from the students. The researcher documented this as follows:

“After the implementation, specifically during the completion of the questionnaire, I observed that some students inadvertently rated the first question—regarding problems encountered—incorrectly. For example, a student rated the scale at 10, indicating that they did not face any problems. However, since the student did not encounter any problems, the rating should have been 1 instead of 10. Upon bringing this to the student's attention, they acknowledged the mistake and corrected it. A few other students made similar errors, but all were eventually corrected. This highlights the importance of clarifying and ensuring accurate responses during the feedback process.” (Ankara, 4th December, 2023, Line Number: 61-68).

3.3.8. Findings from the validity committee meeting records

After each lesson, the researcher collected a series of data about how the lesson went, with a particular focus on the problems encountered and how these problems were addressed. Subsequently, a meeting was convened with the validity committee members to deliberate on the problems identified during the lesson and propose effective solutions. Table 28 succinctly outlines the problems identified during the third implementation and the decisions made by the validity committee members to address these challenges.

Table 28. *Third implementation issues and Validity Committee decisions*

Related Week	Encountered Problems	Action Decisions Taken to Solve Problems	VCM		
			No:	Mins	P
3 rd Week	No problems were observed or encountered by the researcher, and there were no reported problems from the students during the lesson.	Given that no problems were observed, encountered, or reported, this signifies the successful completion of the implementation.	3	90	4

VCM: Validity Committee Meeting; No: Meeting No; Mins: Meeting Duration (Minutes); P: Number of Participants

Throughout the implementation, the researcher has expressed that he did not encounter any problems, nor did he observe any problems during the science lesson integrated with various technological tools. Additionally, the researcher stated that none of the students reported encountering any problems regarding the technological tools utilized during the lesson. These results show that all the action decisions were effective

and helped the science teacher develop his teaching practice while integrating ICTs. As a result, all the validity committee members expressed that the implementation was indeed successful and that all the problems encountered in the previous implementation were addressed. This is what transpired between the validity committee members:

Validity Committee Member 2: We had four meetings with three weeks of implementation. No serious problems arose. This was an opportunity for us to make some observations so you [Numan] can practice your teaching skills. So, [Validity Committee Member 1], what can we say about this? Now, if Validity Committee Member 3 also accepts this implementation, do you think that Numan has taught enough lessons in science with technology by trying different technological tools, based on his experiences and opinions from the students, and now he should complete the implementation of his thesis?

Validity Committee Member 3: I think it's appropriate.

Validity Committee Member 2: For me, Numan's implementation can end here.

Validity Committee Member 1: I agree. It is enough. We had no problem with our observations. Now the analysis can begin.

Validity Committee Member 2: No problem arose. You [Numan] can now proceed with the reporting process. (VCM No. 4).

Consequently, this marked the conclusion of the implementation phase, and all the collected data can now be further analyzed as a single data set to answer the research questions.

3.4. Findings on the Technologies That Were Used to Improve Students' Understanding of Key Science Concepts at the Beginning, During, and at the End of the Implementation Week's Courses in This Study.

The technological tools intended for integration into the lessons were selected based on the instructional objectives of the lesson. These tools were then demonstrated to the validity committee members during preliminary validity committee meetings. After the demonstration, the committee members scrutinized the tools based on their criteria, including their capability to aid in achieving the instructional objectives, their appropriateness for the students' level, their modernity (such as interactive videos and 3D simulations, as opposed to basic 2D simulations), and their utility in assessing individual student understanding in the assessment sections. Only when the committee members deemed the technological tools appropriate were they integrated into the lessons. This process was followed throughout the three-week implementation period for the selection and integration of the technological tools.

During the three-week implementation process, various technological tools were integrated to enhance the students' understanding of scientific concepts. These technological tools included interactive videos, animations, simulations, ESL Game Plus, Wordwall, Kahoot, and technological devices such as smartboards, smartphones, and laptops. These technological tools were integrated into different implementations. Table 29 below highlights the technological tools integrated throughout the 3-week implementation, spanning the beginning, middle, and end of the lessons.

Table 29. *Technological Tools and Reasons for Integration Across Lesson Phases*

Week of Implementation	Beginning <i>Lay foundation, demonstrate simulation tasks, and engage students</i>	Middle <i>Hands-on activities and solidify understanding</i>	End <i>Assess understanding in an interactive and enjoyable way</i>
1	• Video • Animation	• Simulation (PhET) • Simulation (Olabs)	• Wordwall • Kahoot
2	• Video • Animation	• Simulation (PhET)	• Kahoot • ESL Games Plus
3	• Interactive video	• 3D Simulation (CoSpacesEdu)	• Kahoot

Throughout the three-week implementation, various technological tools were integrated into different sections of the lessons, including the beginning, middle, and end. The rationale behind this integration was to enhance the students' understanding of key scientific concepts. The researcher, in his observation protocols, detailed the technological tools integrated during the three-week implementation and the sections in which they were incorporated. According to the researcher's first observation protocol entry, the technological tools integrated into the science lesson included a video, an animation, and two simulations (one from OLABS and the other from PhET), as well as Wordwall and Kahoot. The researcher highlighted the technological tools integrated as follows:

"Various technological tools were integrated in the lesson, including a video, an animation, two simulations [OLABS and PhET], Wordwall, and Kahoot. The video was presented at the outset, while in the middle of the lesson, both the animation and simulations were seamlessly integrated. Finally, during the assessment stage at the end of the lesson, Wordwall and Kahoot were integrated." (Observation Number 1, Date: 20th November, 2023).

Furthermore, the researcher highlighted the technological tools integrated into the lesson in the observation protocol for the second implementation. According to the researcher's entry, the technological tools integrated included a video, an animation, a

simulation, ESL Games Plus, and Kahoot. This is what the researcher recorded in the observation protocol:

“The lesson incorporated various technological tools, including a video, an animation, a simulation, an ESL game, and Kahoot. Initially, a video and animation were presented at the beginning of the lesson. In the middle of the session, the students engaged in a simulation task. Finally, for assessment purposes, an ESL game and Kahoot were employed at the end of the lesson.” (Observation Number 2, Date: 27th November, 2023).

Finally, the researcher elaborated on the technological tools integrated into the science lesson during the third implementation. These included an interactive video, a 3D simulation, and Kahoot. This is what the researcher recorded in the observation protocol:

“Three technological tools were integrated into the lesson: an interactive video, a 3D simulation, and Kahoot. At the beginning of the lesson, the interactive video was presented on the smartboard for the students. In the middle of the lesson, the students carried out a 3D simulation task. At the end of the lesson, Kahoot was used to assess the students' understanding of the lesson.” (Observation Number 3, Date: 4th December, 2023).

Combining the technological tools integrated throughout the three-week implementation reveals that, based on the stage at which they were used, each tool served a distinct purpose. Interactive videos and animations at the beginning of the lessons were intended to lay the groundwork, demonstrate how to carry out subsequent simulation tasks, and engage the students. In the middle of the lessons, 3D and 2D simulations were used to involve students in hands-on activities related to the topic and to solidify their understanding. Finally, various technological tools were used for assessment, including Kahoot, Wordwall, and ESL Games Plus. These assessment tools were integrated to assess the students' understanding, make the lessons interactive, and enhance student enjoyment.

After integrating various technological tools at different stages throughout the science lessons, the researcher observed significant improvements in the students' understanding of key scientific concepts. Additionally, the students expressed various instances where the integrated technological tools enhanced their understanding of the science lessons. These sentiments were elaborated under the following themes:

1. Improved Conceptual Understanding
2. Hands-On Learning Experience
3. Effective Assessment and Feedback

3.4.1. Improved conceptual understanding

Under this theme, the researcher elaborated on how the technological tools integrated throughout the three-week implementation improved students' scientific understanding. The theme also highlights how the integrated technological tools, such as interactive videos and animations, helped the students grasp complex scientific concepts more clearly. The researcher noted that the students' reactions to the videos and animations indicated their understanding of the scientific concepts being taught. This is what the researcher recorded in the observation protocol during the first implementation:

"Following the display of the video at the beginning and the animation in the middle of the lesson, the students were seen nodding their heads in agreement, signaling a clear understanding of the content. Notably, their smiling faces further indicated understanding and enthusiasm for the lesson." (Observation Number 1, Date: 20th November, 2023).

Furthermore, in the researcher's observation protocol entry during the third implementation, it was noted that students exhibited a high level of comprehension of the presented content when interacting with the interactive videos. These videos incorporated pauses for students to engage in calculations and answer questions embedded within the video. The researcher documented this observation in the protocol during the third implementation as follows:

"The students enjoyed the interactive nature of the video and actively participated in the questions it presented. The interactive nature of the video also provided an opportunity for students to inquire about concepts they found challenging, sparking a lively and comprehensive discussion. By the end of the interactive video session, all students expressed a strong sense of understanding of the concepts covered." (Observation Number 3, Date: 4th December, 2023).

Additionally, the researcher noted in the observation field note recorded at the end of the second implementation that the ensuing discussion and question-and-answer session following the integration of video and animation into the lesson reassured him of the technological tools' contribution to the students' understanding of the lesson. This is what the researcher recorded:

"The discussion and question and answer session, along with the feedback received from the students, provided me with complete assurance that the students had a solid grasp of the lesson. I chose to display the animation to reinforce their understanding of the concept and to infuse an element of enjoyment into the lesson. From my observations of the students' facial expressions and demeanour, it was evident that the animation not only enhanced their understanding of the topic but also made the lesson more enjoyable for them." (27th November, 2023, Observation Field Note, Line Number: 30-35).

Additionally, the researcher detailed how the integration of 2D and 3D simulations aided the students in visualizing and comprehending the scientific phenomena under study. In the researcher's observation field note during the second implementation, it was expressed that the integrated simulation proved highly beneficial in assisting the students in understanding and distinguishing between speed and velocity. This is what the researcher recorded:

"I provided the students with a detailed explanation and step-by-step instructions for a simulation task called "Moving Man," sourced from PhET. Their objective was to position the "Moving Man" at a specific location, guide him through a defined distance within a particular time frame, and calculate the resulting speed. The simulation proved highly beneficial, aiding the students in differentiating between speed and velocity. Engaged and collaborative, the students completed the task with enthusiasm, demonstrating a clear understanding of the lesson." (27th November, 2023, Observation Field Note, Line Number: 36-42).

Finally, the researcher also noted in the observation protocol recorded during the third implementation that the integration of 3D simulation into the lesson facilitated the students' understanding of various movements in 3D scenarios. This is what the researcher recorded:

"Upon checking the 3D simulation tasks on the students' laptops and the completed worksheets they presented, it was evident that they had done a marvellous job, completing the task perfectly. From my perspective, this is a great assurance that the technological tools significantly contributed to their understanding of the topic. Furthermore, the 3D simulation proved highly beneficial, helping the students visualize and comprehend various movements in 3D scenarios. The students really enjoyed the task and completed it with enthusiasm, collaborating with their colleagues." (4th December, 2023, Observation Field Note, Line Number: 56-62).

Additionally, in the exit tickets recorded at the end of the lesson, the students expressed that the technological tools, particularly the animations, simulations, Wordwall, and Kahoot, significantly aided their understanding of the lesson. This is what the students recorded:

Student 1: *"Using technology helped me understand things much easier and faster." (Second Week's Exit Ticket of Student 1). "Overall, using technology in science lessons makes it fun and helps you understand better. This learning method also improved my performance." (Third Week's Exit Ticket of Student 1).*

Student 2: *"Then we watched an animation that made us understand how the experiment worked." (First Week's Exit Ticket of Student 2).*

Student 3: “Today’s lesson was very nice. We used different technological tools, for example, videos, animations, simulations, games, and Kahoot. I understand the topic better with my friends. I liked working in groups. I really enjoyed today’s lesson.” (Second Week’s Exit Ticket of Student 3).

Student 4: “Today’s lesson was enjoyable for me. We did simulations that helped me understand the topic. It was fun to do, and in my opinion, we should do more of them. It is a fun way to learn.” (Second Week’s Exit Ticket of Student 4). “Today’s lesson was really fun because we used interactive video, 3D simulation, and Kahoot. I really enjoyed and understood the lesson because of these technologies. I liked the 3D simulation. I hope we should do it every day.” (Third Week’s Exit Ticket of Student 4).

Student 8: “Hello, today’s science lesson was extremely fun because we learned by using technology, which helps you learn better. Moreover, we watched an animation and played Kahoot, which made it more amazing.” (First Week’s Exit Ticket of Student 8). “Today’s lesson was very fun. We answered questions in the interactive video at the beginning of the lesson, which was fun and helped me understand the lesson, especially how to calculate speed. I also enjoyed the 3D simulation and Kahoot.” (Third Week’s Exit Ticket of Student 8).

Furthermore, the students have also expressed their views in the questionnaires they have filled at the end of each lesson how the technological tools used during the lesson helped improved their understanding of the lesson. This is what the students recorded:

Student 4: “It kind of helped because they explained it in an easier way for a person to understand the lesson.” (Answer of Student 4 for the Second Question of the First Week’s Questionnaire). “It was nice. It made me understand and made me learn, and I also had lots of fun in the lesson.” (Answer of Student 4 for the Second Question of the Second Week’s Questionnaire).

Student 5: “Technology is helping to understand the lesson.” (Answer of Student 5 for the Second Question of the Third Week’s Questionnaire).

Student 6: “Good, it helps me understand the lesson more in a fun way.” (Answer of Student 6 for the Second Question of the Second Week’s Questionnaire). “The simulation made me understand more of the topic in the lesson. The videos also helped me learn more. The Kahoot helped me, and in a really fun way.” (Answer of Student 6 for the Second Question of the Third Week’s Questionnaire). “It helped us understand in a really enjoyable and fun way.” (Answer of Student 6 for the Third Question of the Third Week’s Questionnaire).

Student 7: “It made me understand the lesson because technology makes you understand better (animation, etc.).” (Answer of Student 8 for the Second Question of the First Week’s Questionnaire). “I understand well with technology. It helped me to understand how to calculate speed. And how to calculate distance and time during simulation.” (Answer of Student 7 for the Second Question of the Second Week’s Questionnaire). “In my opinion,

technology helped me understand the lesson, such as simulation, video, and Kahoot.” (Answer of Student 7 for the Second Question of the Third Week’s Questionnaire).

Student 8: *“I understand the lesson very well because we used interactive video, 3D simulation, and Kahoot, which made me understand it very well.” (Answer of Student 8 for the Second Question of the Third Week’s Questionnaire).*

During the interviews held with the students at the end of the lessons, they expressed that the technological tools integrated into the lesson significantly helped them understand the lessons. This is what the students shared during the interviews:

Student 1: *“They helped me understand better, and they made the lesson more enjoyable for me because I got to do it with my friends. I think the lesson was more fun than usual. Because I got to understand faster than usual.” (Response of Student 1 During the Second Week’s Focus Group Interview).*

Student 2: *“I think it helped me to understand how the graphs work better and how we can, um, understand the line, the speed, and the distance, and I think it was very clear.” (Response of Student 2 During the Third Week’s Focus Group Interview).*

Student 3: *“It helped me understand better, and it was more interesting, and I think I kind of improved.” (Response of Student 3 During the First Week’s Focus Group Interview). “It expanded my knowledge about speed, distance, and time and how we can calculate them. It helped me understand the topic better. And it was more interesting and fun than the usual lesson.” (Response of Student 3 During the Second Week’s Focus Group Interview).*

Student 4: *“It made me understand, but also in a fun way. And we also learned a lot, and I understood it more than we usually study.” (Response of Student 4 During the Second Week’s Focus Group Interview). “It made me understand very well, and it was also fun, and it’s a fun way to learn with other people. (Response of Student 4 During the Third Week’s Focus Group Interview).*

Student 5: *“Because simulations and animations help, like helping to understand.” (Response of Student 5 During the First Week’s Focus Group Interview).*

Student 6: *“So basically, it helped us learn even better, and it made us focus, in my opinion, because, like, it’s just way more fun.” (Response of Student 6 During the Third Week’s Focus Group Interview).*

3.4.2. Hands-on learning experience

Under this theme, the researcher elaborated on how the integration of 2D and 3D simulations into the lesson enabled the students to apply theoretical concepts practically, thereby reinforcing their understanding. In the observation protocol recorded during the second implementation, the researcher noted that the students expressed a sense of

accomplishment after collaboratively executing a simulation task. This is what the researcher recorded:

“During the middle of the lesson, the students collaboratively conducted a simulation task on their laptops. They expressed a great sense of accomplishment and highlighted that the task not only enhanced their understanding of the lesson but was also enjoyable.”
(Observation Number 2, Date: 27th November, 2023).

Additionally, the researcher noted in the observation protocol recorded during the third implementation that the 3D simulation task completed by the students contributed not only to their understanding but also enhanced their enjoyment of the lesson. This is what the researcher recorded in the third observation protocol:

“In the middle of the lesson, the students worked collaboratively on a 3D simulation task using their laptops, writing a few lines of code. They conveyed a strong sense of accomplishment and emphasized that the task not only deepened their understanding of the lesson but also brought an enjoyable and engaging element to the learning experience.”
(Observation Number 3, Date: 4th December, 2023).

The students also expressed in their exit tickets that the technological tools used during the lesson, especially the animations and simulations, allowed them to see how the experiments were conducted, and this significantly helped them understand the lesson. This is what the students recorded:

Student 1: *“In today’s lesson, we used technological tools and devices to learn about speed. Using technology helped me understand things much easier and faster. I was able to see the experiments and how they were done by the simulation. Additionally, I did it with my friends, which made it more enjoyable. (Second Week’s Exit Ticket of Student 1). “For the simulation, it was interesting because it was 3D. We coded, and then we put our results on a graph and answered questions” (Third Week’s Exit Ticket of Student 1).*

Student 2: *“...Well, the group played a simulation about the lesson to make us feel like we were doing the experiment, and even another simulation.” (First Week’s Exit Ticket of Student 2). “...we opened a 3D simulation on our laptop and worked on it together. My group and I coded and drew the graph.” (Third Week’s Exit Ticket of Student 2).*

In their questionnaire entries, the students also expressed how the technological tools, especially the animation and simulation activities, provided them with good visualization and gave them the feeling that the experiments were being conducted in the real world, which helped them understand the lesson. This is what the students expressed:

Student 1: *“It was easier for me to understand because I could easily see how the experiments were done with the animations and simulations.” (Answer of Student 1 for the Second Question of the First Week’s Questionnaire). “I could understand very fast, and*

especially the simulation we did today was very interesting. It was 3D, and we did coding as well.” (Answer of Student 1 for the Second Question of the Third Week’s Questionnaire).

Student 2: *“It can resemble a real lab experiment, and it gave clear examples and explanations that you can even repeat if you don’t understand.” (Answer of Student 2 for the Second Question of the First Week’s Questionnaire). “It can help us understand as if we are experiencing the simulation. I think technology can help us understand even more.” (Answer of Student 2 for the Second Question of the Second Week’s Questionnaire).*

During the interviews held with the students at the end of the lessons, they expressed that the technological tools integrated into the lessons significantly helped them understand the lesson. This understanding was largely due to how the technological tools, especially animations and simulations, were used to depict how experiments were conducted virtually. This is what the students shared during the interviews:

Student 1: *“Well, they helped me understand better because I was easily able to see the experiment from the simulations and animations. And it affected me in a good way.” (Response of Student 1 During the First Week’s Focus Group Interview). “I think my performance improved because I could clearly see what was going on, and it helped me visualize better.” (Response of Student 1 During the Third Week’s Focus Group Interview).*

Student 3: *“So, when we watched the video, I understood the experiment better. And when we did the simulation, I also understood better.” (Response of Student 3 During the First Week’s Focus Group Interview).*

Student 5: *“Because simulations and animations help, like helping to understand. I understand better because they’re showing how forces and motions work and how they’re working.” (Response of Student 5 During the First Week’s Focus Group Interview). “It helped me to understand the lesson because we played games and there’s some, uh, simulations, and it’s helping to understand the lesson.” (Response of Student 5 During the Third Week’s Focus Group Interview).*

Student 6: *Because, so basically, the simulations and animations just, like, helped me focus better, and yeah, like, because of this technology. (Response of Student 6 During the Second Week’s Focus Group Interview).*

Student 8: *“And also, animations helped us see and visualise it better. And in a fun way. So, it was nice.” (Response of Student 8 During the First Week’s Focus Group Interview). “Uh, it helped me visualize it more and, like, helped me understand it way better.” (Response of Student 8 During the Third Week’s Focus Group Interview).*

3.4.3. Effective assessment and feedback

Under this theme, the researcher elaborated on how the technological tools integrated during the assessment phase of the lesson helped the students monitor their learning progress and reinforce their understanding. The researcher noted that technological tools like Kahoot and Wordwall, utilized during the assessment phase, provided immediate feedback to the students. This feedback helped them understand their learning progress and identify areas needing improvement. The researcher recorded this observation during the third implementation as follows:

“During the assessment phase at the end of the lesson, students individually answered questions on their smartphones with enthusiasm and attentiveness. Notably, the students expressed a desire to participate in more Kahoot activities, showcasing a keen interest in this interactive and engaging form of assessment.” (Observation Number 3, Date: 4th December, 2023).

Additionally, the researcher described how the students completed the assessment during the second implementation. According to the entry made in the observation field note during the second implementation, the students worked collaboratively to complete the assessment task. Their excellent performance assured the researcher that they understood the lesson. This is what the researcher recorded:

“For the assessment stage, I utilized ESL Games Plus and Kahoot as the technological tools. The students began with collaborative participation in ESL Games Plus, where they answered questions displayed on the smartboard alternately between the groups. The ESL games consisted of ten questions, exclusively focused on calculating speed, distance, and time. Impressively, both groups excelled, achieving perfect scores of 5/5 on all questions. What particularly caught my attention was the remarkable collaboration and teamwork displayed by the students. It was a marvellous experience, and this assurance further solidified my belief that the integrated technological tools significantly enhanced the students’ understanding of the lesson.” (27th November, 2023, Observation Field Note, Line Number: 50-58).

Finally, the researcher elaborated on how the gamified nature of assessment tools like Kahoot and ESL Games Plus made the learning enjoyable and helped reinforce the students’ understanding of scientific concepts through a fun and competitive environment. The researcher noted in the observation field note recorded during the second week of implementation that the students really enjoyed the Kahoot activities and wanted to play more. This is what the researcher recorded:

“Towards the end of the lesson, the students collectively answered the ESL game questions, presenting their answers on the smartboard group by group. In the Kahoot session, students

answered questions individually on their smartphones, while those without smartphones were paired with their colleagues who had smartphones. The students thoroughly enjoyed the task and expressed a desire to engage in more Kahoot activities.” (Observation Number 2, Date: 27th November, 2023).

In their exit tickets, recorded at the end of each lesson, the students expressed how the technological tools used during the assessment stage made the lesson more engaging and fun. Here is what the students recorded:

Student 2: *Then we played some games to help us calculate faster and answer faster in general. The games were very enjoyable too, and I would love to do them more.” (Second Week’s Exit Ticket of Student 2). “Finally, we played Kahoot again, but this time, everyone played alone. I got 1st place this time. I’m proud of myself, and I hope for more fun lessons like this.” (Third Week’s Exit Ticket of Student 2).*

The students also expressed during the interviews how the technological tools used in the assessment phase of the lesson helped them understand the lesson and made it enjoyable. This is what the students shared:

Student 8: *“Technology helped me get better grades because, for example, with Kahoot, if there is a question you don’t know, you learn new things from Kahoot.” (Response of Student 8 During the First Week’s Focus Group Interview).*

The students also expressed in their questionnaire entries how the technological tools used in the assessment phase of the lesson helped them understand the lesson and made it enjoyable. This is what the students shared:

Student 3: *“It was better and more fun when we used a computer and phone for Kahoot. I understood everything.” (Answer of Student 3 for the Second Question of the Second Week’s Questionnaire). “It was very nice; we worked in groups, and I also like Kahoot. It was effective because we repeated the materials we did before.” (Answer of Student 3 for the Second Question of the Third Week’s Questionnaire).*

3.5. Findings on the Students’ Views on Technology-Supported Science Learning Activities.

Throughout the three-week implementation of science lessons integrated with various technological tools, the students have expressed diverse views, insights, and preferences regarding the integration of technology into their science lessons. These views were gathered through focus-group interviews, exit tickets, and questionnaire responses recorded by the students at the end of each lesson. Through this data, the researcher gained a comprehensive understanding of the students' views and perspectives on the use of technology in science instruction. The themes that emerged from the

students' views on the integration of technological tools in science learning activities are illustrated below:

1. Enjoyment of Interactive Elements
2. Enhanced Comprehension
3. Improvement in Performance
4. Positive Emotional Response
5. Advocacy for Continued Implementation

3.5.1. Enjoyment of interactive elements

Under this theme, the students articulated numerous ways in which the integrated technological tools made the lesson enjoyable for them. The students' views centered on the enjoyment of the interactive elements, highlighting the positive influence of incorporating interactive features like simulations, animations, and educational games on their overall enjoyment of the learning experience. The students exhibited heightened stimulation and interest in the lesson when interactive technological tools were utilized. This enjoyment not only enriched their learning experience but also fostered active participation and sustained focus during lessons. The students expressed the following views in the questionnaire they recorded in this regard:

Student 1: *"It was more fun because we played games about it, and it was easier for me to understand. Also, the games were more fun with group work." (Answer of Student 1 for the Third Question of the First Week's Questionnaire). "It helped me understand better, and we also did the simulation with my classmates, which made it more fun. But Kahoot was my favorite; it was fun, and it made me understand the best." (Answer of Student 1 for the Third Question of the Third Week's Questionnaire).*

Student 2: *"It contained fun simulations that were easy to understand and enjoyable. It was very clear to me and helped my understanding." (Answer of Student 2 for the Third Question of the First Week's Questionnaire). "Because we are doing simulations and games, it can be enjoyable and fun at the same time." (Answer of Student 2 for the Third Question of the Second Week's Questionnaire). "In my opinion, it can clear any confusion you have and provide good examples that explain very well." (Answer of Student 2 for the Third Question of the Third Week's Questionnaire).*

Student 3: *"Yes, I liked it. It was also nice when we used phones for Kahoot. I also like the animation." (Answer of Student 3 for the Third Question of the Second Week's Questionnaire). "It is very enjoyable; we did Kahoot. I really liked it. I also liked the simulation." (Answer of Student 3 for the Third Question of the Third Week's Questionnaire).*

Student 4: *"It was enjoyable because we had different types of stuff to do." (Answer of Student 4 for the Third Question of the First Week's Questionnaire). "It was enjoyable and fun to do. I think we should do more of them." (Answer of Student 4 for the Third Question of the Second Week's Questionnaire). "It was really fun, and in my opinion, we should do it again." (Answer of Student 4 for the Third Question of the Third Week's Questionnaire).*

Student 5: *"It was enjoyable because we played games and we learned [about] Newton, and it is fun." (Answer of Student 5 for the Third Question of the First Week's Questionnaire). "Yes, it is enjoyable because we played games." (Answer of Student 5 for the Third Question of the Second Week's Questionnaire). "Yes, the lesson was enjoyable because we played Kahoot." (Answer of Student 5 for the Third Question of the Third Week's Questionnaire).*

Student 6: *"Of course! The lesson is more fun and enjoyable. The technologies made the lesson more fun, especially Kahoot." (Answer of Student 6 for the Third Question of the Second Week's Questionnaire). "It helped us understand in a really enjoyable and fun way." (Answer of Student 6 for the Third Question of the Third Week's Questionnaire).*

Student 7: *"In my opinion, it was enjoyable. We have some games, such as Kahoot and Wordwall. It was funny." (Answer of Student 7 for the Third Question of the First Week's Questionnaire). "Good, because technology helped us a lot. It was enjoyable, and at the end of the lesson, we played Kahoot." (Answer of Student 7 for the Third Question of the Second Week's Questionnaire). "I enjoyed because of Kahoot." (Answer of Student 7 for the Third Question of the Third Week's Questionnaire).*

Student 8: *"Using technology makes enjoyment because it is like a game and it is very fun to use. So, using technology is extremely enjoying." (Answer of Student 8 for the Third Question of the First Week's Questionnaire). "In my opinion, today's lesson was very enjoyable because of Kahoot." (Answer of Student 8 for the Third Question of the Third Week's Questionnaire).*

Additionally, the students expressed in the exit tickets recorded at the end of each implementation how the integrated technological tools made the lessons enjoyable for them. The sentiments expressed by the students in their exit tickets are as follows:

Student 1: *"I was able to see the experiments and how they were done by the simulation. Additionally, I did it with my friends, which made it more enjoyable." (Second Week's Exit Ticket of Student 1). "It also makes the lesson more fun because we can interact, just like we did with the video, simulation, and Kahoot. We watched the video, paused it, and answered some questions. For the simulation, it was interesting because it was 3D. We coded, and then we put our results on a graph and answered questions. And in Kahoot, we solved questions and had to be fast, which I think made it fun." (Third Week's Exit Ticket of Student 1).*

Student 8: *"Hello, today's science lesson was extremely fun because we learned by using technology, which helps you learn better. Moreover, we watched an animation and played Kahoot, which made it more amazing." (First Week's Exit Ticket of Student 8). "Today's lesson was very fun. We answered questions in the interactive video at the beginning of the*

lesson, which was fun and helped me understand the lesson, especially how to calculate speed. I also enjoyed the 3D simulation and Kahoot.” (Third Week’s Exit Ticket of Student 8).

During the interviews held with the students at the end of each lesson, they also expressed how the integrated technological tools made the lesson enjoyable for them. These are the sentiments the students expressed:

Student 1: *“It made the lesson more fun and interesting, and it made everything easier to understand because I could see it and how it was done.” (Response of Student 1 During the Third Week’s Focus Group Interview).*

Student 3: *“Uh, it was more interesting and enjoyable than it usually is, and a lot more.” (Response of Student 3 During the Third Week’s Focus Group Interview).*

Student 4: *“It made me understand very well, and it was also fun, and it’s a fun way to learn with other people.” (Response of Student 4 During the Third Week’s Focus Group Interview).*

Student 6: *So basically, it helped us learn even better, and it made us focus, in my opinion, because, like, it’s just way more fun. (Response of Student 6 During the Third Week’s Focus Group Interview).*

Student 7: *“Uh, first we watched the video; it was like, uh, I learned more about this kind of movement, and at the end of the lesson, we do some Kahoot. It was fun and enjoyable.” (Response of Student 7 During the Third Week’s Focus Group Interview).*

Student 8: *“And also, animations helped us see and visualise it better. And in a fun way. So, it was nice. It’s fun. It’s nice. It helps you learn better. Yeah. (Response of Student 8 During the First Week’s Focus Group Interview).*

3.5.2. Enhanced comprehension

This theme highlights the role of integrated technological tools in facilitating understanding and providing clear explanations for students. It emphasizes how these tools assisted the students in grasping scientific concepts more effectively and visualizing complex ideas with greater clarity. Under this theme, the students emphasized their improved understanding of the lesson facilitated by the integrated technological tools. Through the use of simulations, animations, and interactive activities, the students found it easier to grasp complex concepts and visualize abstract ideas. Their sentiments were expressed as follows:

Student 1: *“It was easier for me to understand because I could easily see how the experiments were done with the animations and simulations.” (Answer of Student 1 for the Second Question of the First Week’s Questionnaire). “I could easily see how the experiments were done by the simulations.” (Answer of Student 1 for the Second Question of the Second Week’s Questionnaire). “I could understand very fast, and especially the simulation we did*

today was very interesting. It was 3D, and we did coding as well.” (Answer of Student 1 for the Second Question of the Third Week’s Questionnaire).

Student 2: *“It can resemble a real lab experiment, and it gave clear examples and explanations that you can even repeat if you don’t understand.” (Answer of Student 2 for the Second Question of the First Week’s Questionnaire). “It can help us understand as if we are experiencing the simulation. I think technology can help us understand even more.” (Answer of Student 2 for the Second Question of the Second Week’s Questionnaire). “It helped me understand the graphs and the topic very well. And it was also very enjoyable and fun.” (Answer of Student 2 for the Second Question of the Third Week’s Questionnaire).*

Student 3: *“It was a little more interesting than usual lessons.” (Answer of Student 3 for the Second Question of the First Week’s Questionnaire). “It was better and more fun when we used a computer and phone for Kahoot. I understood everything.” (Answer of Student 3 for the Second Question of the Second Week’s Questionnaire). “It was very nice; we worked in groups, and I also like Kahoot. It was effective because we repeated the materials we did before.” (Answer of Student 3 for the Second Question of the Third Week’s Questionnaire).*

Student 4: *“It kind of helped because they explained it in an easier way for a person to understand the lesson.” (Answer of Student 4 for the Second Question of the First Week’s Questionnaire). “It was nice. It made me understand and made me learn, and I also had lots of fun in the lesson.” (Answer of Student 4 for the Second Question of the Second Week’s Questionnaire). “It was understanding and easy to use.” (Answer of Student 4 for the Second Question of the Third Week’s Questionnaire).*

Student 5: *“It helped me because there were questions and some video games, and it helped me understand.” (Answer of Student 5 for the Second Question of the First Week’s Questionnaire). “It’s helping to learn the unit.” (Answer of Student 5 for the Second Question of the Second Week’s Questionnaire). “Technology is helping to understand the lesson.” (Answer of Student 5 for the Second Question of the Third Week’s Questionnaire).*

Student 6: *“Good, it helps me understand the lesson more in a fun way.” (Answer of Student 6 for the Second Question of the Second Week’s Questionnaire). “The simulation made me understand more of the topic in the lesson. The videos also helped me learn more. The Kahoot helped me, and in a really fun way.” (Answer of Student 6 for the Second Question of the Third Week’s Questionnaire).*

Student 7: *“I think technology helped us. It was informative and, at the same time, funny. I understand all.” (Answer of Student 7 for the Second Question of the First Week’s Questionnaire). “I understand well with technology. It helped me to understand how to calculate speed. And how to calculate distance and time during simulation.” (Answer of Student 7 for the Second Question of the Second Week’s Questionnaire). “In my opinion, technology helped me understand the lesson, such as simulation, video, and Kahoot.” (Answer of Student 7 for the Second Question of the Third Week’s Questionnaire).*

Student 8: *“It made me understand the lesson because technology makes you understand better (animation, etc.).” (Answer of Student 8 for the Second Question of the First Week’s*

Questionnaire). “I understand the lesson very well because we used interactive video, 3D simulation, and Kahoot, which made me understand it very well.” (Answer of Student 8 for the Second Question of the Third Week’s Questionnaire).

During the focus group interviews held with the students at the end of the implementations, the students also expressed how the integrated technological tools helped improve their understanding of the lesson. These are the sentiments the students expressed during the interviews:

Student 1: “They helped me understand better, and they made the lesson more enjoyable for me because I got to do it with my friends. I think the lesson was more fun than usual. Because I got to understand faster than usual.” (Response of Student 1 During the Second Week’s Focus Group Interview).

Student 2: “I think it helped me to understand how the graphs work better and how we can, um, understand the line, the speed, and the distance, and I think it was very clear.” (Response of Student 2 During the Third Week’s Focus Group Interview).

Student 3: “It helped me understand better, and it was more interesting, and I think I kind of improved. So, when we watched the video, I understood the experiment better. And when we did the simulation, I also understood better.” (Response of Student 3 During the First Week’s Focus Group Interview).

Student 7: “It helped me on how to calculate speed, distance, and time. I think Kahoot helped me much better to understand because it helped me to be able to answer faster.” (Response of Student 7 During the Second Week’s Focus Group Interview).

In the exit tickets recorded by the students at the end of each lesson, they also expressed how the integrated technological tools helped improve their understanding. This is what the students recorded in that regard:

Student 1: “In today’s lesson, we learned about describing movement using an interactive video, 3D simulation, and Kahoot. I think the use of technology helps me a lot with visualizing. Overall, using technology in science lessons makes it fun and helps you understand better. This learning method also improved my performance.” (Third Week’s Exit Ticket of Student 1).

Student 3: “Today’s lesson was very nice. We used different technological tools, for example, videos, animations, simulations, games, and Kahoot. I understand the topic better with my friends. I liked working in groups. I really enjoyed today’s lesson.” (Second Week’s Exit Ticket of Student 3).

Student 4: “Today’s lesson was really fun because we used interactive video, 3D simulation, and Kahoot. I really enjoyed and understood the lesson because of these technologies. I liked the 3D simulation. I hope we should do it every day.” (Third Week’s Exit Ticket of Student 4).

3.5.3. Improvement in performance

This theme underscores how the integration of technological tools positively improves the students' academic achievements. This encompasses enhancements in grades, confidence, and overall academic performance as perceived by the students themselves. One subtheme emerged under this theme, which was academic progress. The students express how the integrated technological tools improved their academic performance as follows:

Student 1: *I think my performance improved because I could clearly see what was going on, and it helped me visualize better. (Response of Student 1 During the Third Week's Focus Group Interview).*

Student 2: *Um, I think the performance was great and better than last time. I think that the grade is good. Very good. (Response of Student 2 During the First Week's Focus Group Interview).*

Student 3: *So, when we watched the video, I understood the experiment better. And when we did the simulation, I also understood better. It helped me understand better, and it was more interesting, and I think I kind of improved. (Response of Student 3 During the First Week's Focus Group Interview).*

Student 4: *I think it also improved. In a fun way. I think technological tools, videos, animations, and simulations from PhET. All of them, like, helped me improve. (Response of Student 4 During the Second Week's Focus Group Interview).*

Student 5: *Because simulations and animations help, like helping to understand. I understand better because they're showing how forces and motions work and how they're working. (Response of Student 5 During the First Week's Focus Group Interview).*

Student 6: *I think it has improved my grades. Because it helps me, like it's more interesting. The lesson's become more interesting. And I think it has helped me improve my grades. (Response of Student 6 During the Second Week's Focus Group Interview).*

Student 7: *I think my performance improved, and I can answer the questions well. (Response of Student 7 During the Third Week's Focus Group Interview).*

Student 8: *Technology helped me get better grades because, for example, with Kahoot, if there is a question you don't know, you learn new things from Kahoot. And from animations and simulations, you see, erh, it helps you memorise it better. So yeah. (Response of Student 8 During the First Week's Focus Group Interview).*

3.5.4. Positive emotional response

This theme elucidates how the integration of technological tools in the learning environment affected the students' emotional states. Through interactive and engaging activities facilitated by these tools, the students experienced positive emotions such as

happiness, satisfaction, and increased focus. Additionally, the integration of technological tools not only enhanced academic engagement but also contributed to the students' overall well-being by fostering positive emotional responses during learning activities. Additionally, the students expressed how the use of technological tools in the lesson elicited favourable emotional reactions from them. This emotional positivity is crucial for fostering a conducive learning environment and enhancing overall student engagement and satisfaction. This is what the students expressed about how the integrated technological tools made them feel:

Student 1: *Well, they helped me understand better because I was easily able to see the experiment from the simulations and animations. And it affected me in a good way. (Response of Student 1 During the First Week's Focus Group Interview). I think the lesson was more fun than usual. Because I got to understand faster than usual. (Response of Student 1 During the Second Week's Focus Group Interview). I was also happy because, if there was a question I didn't understand, I could just do it with my friends and I would understand better. So overall, it was good. (Response of Student 1 During the Third Week's Focus Group Interview).*

Student 2: *I think, I feel, um, I don't know, I feel normal about them. They enhanced my learning. Because it's like in a way that isn't just writing, is in a way that I have more fun with, and also is a way that I'm more comfortable with, so [inaudible]. (Response of Student 1 During the First Week's Focus Group Interview). Probably very happy, and I think more focused on the lesson. Because it was entertaining and enjoyable. (Response of Student 2 During the Third Week's Focus Group Interview).*

Student 3: *So, I felt better. Yeah, it was more interesting. (Response of Student 3 During the Second Week's Focus Group Interview). Uh, it was more interesting and enjoyable than it usually is, and a lot more. (Response of Student 3 During the Third Week's Focus Group Interview).*

Student 4: *It made me feel great. And it also made me feel happy because, like, we had more fun. (Response of Student 4 During the Second Week's Focus Group Interview). It made me feel great. Because it was fun. And we get to play Kahoot. (Response of Student 4 During the Third Week's Focus Group Interview).*

Student 5: *It feels happy because, uh, we did some <inaudible>, we did some questions, and it feels happy. (Response of Student 5 During the Third Week's Focus Group Interview).*

Student 6: *Happy. And it made me, like, happy, yeah. Because, so basically, the simulations and animations just, like, helped me focus better, and yeah, like, because of this technology. (Response of Student 6 During the Second Week's Focus Group Interview). It made me feel very happy, energetic, and fun. (Response of Student 6 During the Third Week's Focus Group Interview).*

Student 7: *I feel good and funny because, like some games, it was also like a lesson, but in the lesson, we were sitting in a group, it was funny and informative. (Response of Student 7*

During the First Week's Focus Group Interview). The lesson's both funny and enjoyable. (Response of Student 7 During the Second Week's Focus Group Interview). Um, I was happy and focused more. (Response of Student 7 During the Third Week's Focus Group Interview).

Student 8: *Uh, it made me feel very happy, and it was a very fun way of learning, in my opinion. (Response of Student 8 During the Third Week's Focus Group Interview).*

3.5.5. Advocacy for continued implementation

This theme highlights the students advocating for the ongoing integration of technological tools into their science learning experiences. The students express a desire to maintain the utilization of these tools due to their perceived benefits, such as increased engagement, enjoyment, and improved understanding. They emphasize the importance of incorporating technological tools like simulations, animations, and interactive quizzes to enhance the learning process. The students expressed a preference for continued implementation, emphasizing the positive impact of technological tools on engagement, comprehension, and overall enjoyment of lessons. This is what the students expressed in that regard:

Student 1: *I think it's a lot better that way. It's more enjoyable for me and my friends. I was able to learn with my friends, and I could see the experiment easily and how it's done. (Response of Student 1 During the First Week's Focus Group Interview). I think we should continue because it makes the lesson a lot more fun. And, like, I can see how the experiment is done with the video, animation, and simulation. I think it's really good. (Response of Student 1 During the Second Week's Focus Group Interview). I think it makes the lesson more enjoyable and easier to understand. (Response of Student 1 During the Third Week's Focus Group Interview).*

Student 2: *I think they would improve the grade and performance of the student better because it is more fun than just working on the book. And I feel like, as soon as we did it with friends, it would also be a lot more enjoyable that way. So, I think I encourage it. (Response of Student 2 During the First Week's Focus Group Interview). I think we should continue using them a lot because they make the lesson a lot more enjoyable that way. And that's because some people don't just simply learn with the book, like me. So, my understanding improved when we used technological tools. So yeah, I think we should continue with them. (Response of Student 2 During the Second Week's Focus Group Interview). I think it's really nice and enjoyable, and we should have a lot more of it. (Response of Student 2 During the Third Week's Focus Group Interview).*

Student 3: *It was more interesting. And I think we should do more Kahoot. (Response of Student 3 During the First Week's Focus Group Interview). I think we should continue using technological tools because it's more interesting that way, and you can understand the topic*

better. (Response of Student 3 During the Second Week's Focus Group Interview). It was more interesting and enjoyable, and we should do more Kahoot. (Response of Student 3 During the Third Week's Focus Group Interview).

Student 4: *It's fun, and it's good. It's a fun way to learn. Yes, we should start using it. Because it will be a fun experiment, erh, experience to do all of that. (Response of Student 4 During the First Week's Focus Group Interview). I think we should do it more. Because it's a fun way to learn with, like, a lot of people, your friends, and your classmates. (Response of Student 4 During the Second Week's Focus Group Interview). It was really good because we got to play Kahoot. (Response of Student 4 During the Third Week's Focus Group Interview).*

Student 5: *It's good. Because it's helping to learn fast, like, it's helping to learn. Yeah. (Response of Student 5 During the First Week's Focus Group Interview). Yeah, because it's helping me understand the lesson. Animation and videos are helping. (Response of Student 5 During the Second Week's Focus Group Interview). It is good. We need to do all the lessons. (Response of Student 5 During the Second Week's Focus Group Interview).*

Student 6: *The use of technology? Yeah, I think we should keep using it because it's more interesting and helps us learn better. They should stay. And we should keep using the technological tools, especially simulations from PhET and Kahoot. (Response of Student 6 During the Second Week's Focus Group Interview). The use of technology? I guess Kahoot helped us; in my opinion, it helped us learn the most because it was fun. (Response of Student 6 During the Third Week's Focus Group Interview).*

Student 7: *In my opinion, the book is kind of boring and not interesting. But when you're using technology tools, it's much more fun and enjoyable. (Response of Student 7 During the Second Week's Focus Group Interview). It was interesting, and I said we need to do more Kahoot. (Response of Student 7 During the Third Week's Focus Group Interview).*

Student 8: *It's fun. It's nice. It helps you learn better. Yeah. Because, like, as Student 4 said, it's for me to experience, and I think it's a better way to learn. (Response of Student 8 During the First Week's Focus Group Interview). I think, uh, it's very fun, and uh, mostly Kahoot made me learn more. (Response of Student 8 During the Third Week's Focus Group Interview).*

In the exit tickets recorded by the students at the end of each implementation, they expressed their approval of the integrated technological tools. In general, the students indicated that these tools should continue to be integrated into the lessons. This is what the students wrote:

Student 2: *"...then we played some games to help us calculate faster and answer faster in general. The games were very enjoyable too, and I would love to do them more." (Second Week's Exit Ticket of Student 2). "Finally, we played Kahoot again, but this time, everyone played alone. I got 1st place this time. I'm proud of myself, and I hope for more fun lessons like this." (Third Week's Exit Ticket of Student 2).*

Student 3: “Today’s lesson was very good. In the beginning of the lesson, we watched a video about describing movement. While watching the video, we sometimes paused and answered the questions. The next thing we did was observe 3D simulations. After that, we did Kahoot. I really liked it. I think we should do more Kahoot.” (Third Week’s Exit Ticket of Student 3).

Student 4: “Today’s lesson was really fun because we used interactive video, 3D simulation, and Kahoot. I really enjoyed and understood the lesson because of these technologies. I liked the 3D simulation. I hope we should do it every day.” (Third Week’s Exit Ticket of Student 4).

Student 6: “The technologies helped me focus more on our lessons in a fun way. The videos helped, and the animation also helped. But mostly Kahoot and the simulation. The ESL games are also pretty good. The technology should stay in class.” (Second Week’s Exit Ticket of Student 6).

3.6. Findings on How the Lesson Plans Are Organized with Technology Integration in the Science Lesson.

Throughout the three-week implementation, three lesson plans were developed to guide the science lessons integrated with various technological tools. A crucial aspect of the lesson plans was that after each implementation, action plans addressing encountered difficulties were incorporated based on decisions made during validity committee meetings. The themes that emerged and guided the organization of the lesson plans are illustrated below:

1. Technology Integration Timeline
2. Individual Assessment
3. Integrate Limited Technological Tools
4. Develop and Integrate Modern Technological Tools

3.6.1. Technology integration timeline

In the lesson plans developed to guide the delivery of the science lessons integrated with various technological tools, provisions were made for numerous sections. Among these sections was the time allocated for delivering the lesson, which was set at 80 minutes for each implementation. However, the breakdown of these 80 minutes was not provided in the lesson plans. Consequently, this led to issues with time management, as there was no guidance on the timing of individual activities stipulated in the lesson plan. The validity committee members deliberated on this issue and suggested that a technology integration timeline be developed and used alongside the lesson plans to guide the lesson delivery. This is what validity committee member 2 stated in this regard:

“To address the time problem, review the entire lesson plan and calculate how many minutes each stage will take on average.” (VCM No. 2).

3.6.2. Individual assessment

In the developed lesson plans, provisions were made to assess the students’ understanding at the end of each lesson. Consequently, technological tools such as Kahoot, Wordwall, and ESL Game Plus were integrated for student assessments. However, during the first and second implementations, individual students were not exclusively assessed after the lessons. The validity committee members pointed out that assessing students collaboratively makes it difficult to determine each student's individual understanding. This is what a validity committee member 3 stated:

“During the evaluation phase, you separated them into groups. I wonder if these groups held discussions before responding, or how did they proceed? When it comes to groups, sometimes a very good student in the group might dominate the discussion, and the other students do not provide any answers. As a result, the students who are smart or very hardworking answer almost immediately, while the other students remain silent. This makes it difficult to evaluate them accurately.” (VCM No. 3).

The validity committee members suggested that individual assessment was necessary to accurately assess each student's understanding of the lesson. To address this, validity committee member 2 recommended using Kahoot for individual assessments, allowing the students to participate individually using their mobile phones. The implementation of this strategy was proposed for subsequent lessons. This is what validity committee member 2 said:

“Why are you collaborating on the assessment? Because you said you use collaborative learning and social constructivism. But there is no constructivism here. This is teacher-centered education. Therefore, I recommend that you make an individual assessment here. Maybe you can do two separate things: an individual and a group assessment. Because we normally assess both individual performance and group performance in group work and cooperative learning, I think you can use Kahoot for individual assessment.” (VCM No. 2).

Provisions were made in the third lesson plan to use Kahoot to assess the individual understanding of the students. At the end of the third implementation, the individual understanding of the students was successfully assessed. This was made possible due to a model proposed by the validity committee member 2. She proposed that the “Bring Your Tablet” model be implemented in which the students and their parents are informed in

advance to bring their tablets or smartphones to schools for a lesson. This is what the validity committee member 2 stated:

“There is a "Bring Your Tablet" program abroad, especially in Europe and America. Students are informed beforehand to bring their tablet devices to class. It is explained that technology will be used in class that week, and they will need to bring their tablets to the classroom. We need to implement this model, ensuring that every student brings their device to class.” (VCM No. 3).

3.6.3. Integrate limited technological tools

Various technological tools were integrated into the science lessons. These tools were specified in the lesson plans, along with the stages at which they would be integrated. The integration of numerous technological tools, such as a video, animation, two simulations, Wordwall, and Kahoot, during the first implementation led to time constraints. As a result, some post-instructional activities, like students recording exit tickets, could not be completed at the stipulated time. Validity committee member 2 expressed that the aim of the study was to investigate effective ways of integrating technological tools into science instruction, not to integrate a large number of tools. This is what validity committee member 2 stated:

“We do not have to use technology at every stage of the lesson. We aim to integrate technology effectively, but it is not mandatory to use it at every stage of the course. I think you can use either Kahoot or Wordwall; you don't really need both.” (VCM No. 2).

Validity committee member 3 also concurred with the view of validity committee member 2. According to validity member 3, It is not necessary to use too many animations and simulations. One or two simulations will suffice. This is what validity committee member 2 said:

“It is not necessary to include too many animations and simulations. Including one or two simulations would be enough.” (VCM No. 2).

Based on the suggestions of the validity committee members, the researcher decided to integrate only a limited number of technological tools, which included an interactive video, a 3D simulation, and Kahoot. This is what the researcher recorded in the post-implementation reflection journal after the third implementation:

“I incorporated an interactive video, a 3D simulation, and Kahoot into the lesson. Unlike previous occasions, I didn't use a plethora of tools this time, as the ones integrated proved to be sufficient in aiding the achievement of the instructional objectives.” (Ankara, 4th December, 2023, Line Number: 4-6).

In her exit ticket, Student 2 characterized the science lesson, integrated with various technological tools, as enjoyable. Despite the smaller number of integrated tools compared to the previous lessons, she emphasized that the experience was equally fun. The integrated technological tools included an interactive video, 3D simulation, and Kahoot. Additionally, Student 2 elaborated on how these tools were utilized, mentioning collaborative completion of questions on the interactive video and 3D simulation, along with individual completion of the Kahoot assessment task. Expressing happiness for achieving first place in the Kahoot assessment, Student 2 expressed hope for more enjoyable lessons like this in the future. The exit ticket of Student 2 is as follows:

“Our science lesson was very nice. Even though we had shorter tools used in this lesson, it was equally fun as the previous lesson. This time we had an interactive video where we answered the questions. After that, we opened a 3D simulation on our laptop and worked on it together. My group and I coded and drew the graph. Finally, we played Kahoot again, but this time, everyone played alone. I got 1st place this time. I’m proud of myself, and I hope for more fun lessons like this.” (Third Week’s Exit Ticket of Student 2).

3.6.4. Develop and integrate modern technological materials

All the technological tools integrated into the lessons were already developed by others and readily available on the internet. Validity committee member 2 suggested that the researcher take on the challenge of developing and integrating at least one advanced technological tool independently. This suggestion stemmed from the observation that the existing tools were deemed too basic and outdated. This is what validity committee member 2 said:

“You can use a different medium. You can use a different tool. You can use 3D simulation. These are very old technologies [the ones you are currently using]. We try to keep up with current technology. If you can find an alternative, better virtual lab and three-dimensional simulation, I think you will be able to make this subject much better for the children.” (VCM No. 2).

The researcher was encouraged to explore the creation of 3D simulations, interactive videos, virtual reality, and similar innovations to introduce a higher level of technological sophistication into the lesson. This step aligns with the overarching goal of the research, which focuses on integrating technology into science education.

Additionally, when integrating technological tools into the lesson, it must be ensured that the tools, especially the simulations, are not too easy for the students. If the tasks are too simple, students might complete them quickly and then engage in activities

unrelated to the lesson, as observed in this current study. Validity committee member 2 suggested giving the students more challenging tasks. This is what validity committee member 2 said during the meeting:

"It's all very easy. While performing the simulation, students open windows. This came very easily to the children. Should we make it a little harder? If it is that easy, there is a problem. There needs to be some challenge for learning." (VCM No. 2).

Validity committee member 2 recommended that in subsequent lessons, challenging simulation tasks should be selected for the students to ensure they spend more time on the task, preventing them from finishing quickly and diverting to unrelated activities.

In the pre-implementation reflection journal recorded by the researcher before the third implementation, he noted that he had developed a 3D simulation using the CoSpacesEdu platform. This initiative stemmed from the suggestions of the validity committee members. Here is what the researcher recorded:

"Additionally, I have developed a 3D simulation using CoSpacesEdu, aiming to facilitate hands-on tasks for the students. This simulation, personally crafted, aligns perfectly with the lesson's objectives." (Ankara, 4th December, 2023, Line Number: 14-16).

Based on the above findings, certain factors must be taken into consideration when organizing lesson plans with technology integration in science lessons. First and foremost, the time allocated for individual activities during the lesson should be clearly stated in the lesson plan, or a technology integration timeline should be developed to be used alongside the lesson plan. Secondly, provisions must be made to assess the individual understanding of students at the end of the lesson. Thirdly, a limited number of technological tools that align perfectly with the instructional objectives should be selected and integrated into the lesson. Finally, the researcher should strive to develop technological material to be integrated into the lesson. While doing this, it must be ensured that the technological tools and materials integrated into the lesson are sufficiently challenging to engage the students. If the tools are too easy, students will complete their tasks quickly and then engage in unrelated activities during the lesson.

3.7. Findings on the Problems Encountered in the Process of Integrating Technology into Science Lessons and Their Solutions.

The integration of technology into the science lessons encountered some challenges, prompting strategic decisions to ensure their seamless integration. These problems were presented to the validity committee members during meetings. During these meetings, solutions were sought, and action plans were implemented in subsequent lessons to address the issues. The problems encountered during the three-week implementation and how they were resolved are illustrated below:

1. Techno-Centric Distractions
2. Time Constraints
3. Excessive Technology Integration
4. Contradictory Questionnaire Responses
5. Preference for Computer Peripheral Functionality
6. Difficulty in Assessing Individual Students' Understanding

3.7.1. Techno-centric distractions

The issue of techno-centric distraction arose when students became overly engrossed in the technological tools integrated into the lesson, particularly the simulations. During the lesson, students were given simulation tasks to complete. The students finished these tasks quickly and then engaged in different activities unrelated to the lesson. While one group became overly engrossed in a different simulation task, a student from another group opened a new window on the laptop meant for the simulation task and started surfing the internet. This behavior led to various forms of distraction, diverting their attention away from the lesson and toward the technological tools. The researcher elaborated on this challenge and how he mitigated it in his observation field note as follows:

“The issue of techno-centric disruptions surfaced as students became overly engrossed in the technological tools, particularly the simulations, diverting their attention away from the teacher and the core lesson content. Even after the designated task, some students continued to engage in unrelated activities on their laptops, detracting from the ongoing lesson.” (20th November, 2023, Observation Field Note, Line Number: 90-93).

While still in the classroom, the researcher devised some ways to solve the problem and regain the attention of the students so they could focus on the lesson. According to the entry made by the researcher in the observation field note recorded at the end of the

first implementation, the researcher expressed that he minimized all the opened windows on the laptop and put the laptop to sleep. This strategy was able to get the students to pay attention to the lesson. This is what the researcher recorded:

“To address this challenge, I implemented a solution by minimizing all open windows and putting the laptops to sleep during periods when the students were supposed to focus solely on the teacher and participate in the lesson. This approach effectively redirected their attention back to the lesson, fostering increased participation and attentiveness. Laptops were only opened and utilized during specific sections of the lesson, such as when carrying out simulation tasks or playing Kahoot.” (20th November, 2023, Observation Field Note, Line Number: 93-99).

The issue of techno-centric distractions was presented to the validity committee members. During the validity committee meeting, validity committee member 2 suggested that perhaps the simulation tasks given to the students were too easy, leading them to complete the tasks quickly and engage in unrelated activities. Validity committee member 2 suggested giving the students a challenging task. This is what validity member 2 said during the meeting:

“It's all very easy. While performing the simulation, students open windows. This came very easily to the children. Should we make it a little harder? If it is that easy, there is a problem. There needs to be some challenge for learning.” (VCM No. 2).

Validity committee member 2 recommended that in subsequent lessons, challenging simulation tasks should be selected for the students to ensure they spend more time on the task, preventing them from finishing quickly and diverting to unrelated activities. The recommendation from the validity committee members was implemented in the subsequent implementation, and the issue of techno-centric distraction was not observed again.

3.7.2. Time constraints

One of the problems encountered by the researcher was time constraints, primarily arising from challenges in managing time due to the integration of technological tools into the lesson. In the observation field note recorded by the researcher at the end of the first implementation, the researcher elaborated on how the arrangement of the classroom to accommodate the technological tools for the science lesson took a significant amount of time from the lesson. This resulted in the students' inability to complete their exit

tickets in class immediately after the lesson. This is what the researcher recorded in that regard:

“The issue of time posed a notable challenge. It took nearly twenty minutes to arrange the seating, set up the students' laptops, and open and log into the various technological tools, including the Cambridge Lower Secondary Science Stage 8 software.” (20th November, 2023, Observation Field Note, Line Number: 80-83).

“Time constraints resulting from the integration of numerous tools meant that the original lesson plan could not be fully executed. Additionally, due to the lack of time, the students were unable to complete the exit ticket in the classroom. Completing this reflection task within the classroom setting would have allowed them to share their experiences while the lesson was still fresh in their minds.” (20th November, 2023, Observation Field Note, Line Number: 85-89).

The researcher further elaborated in the observation field note recorded at the end of the first implementation that, in order to solve the issue of time constraints, he utilized the break time to open and log into the technological tools that the students would use after the break in order to save some time during normal lesson times. This is what the researcher recorded:

“To address this concern, I adapted by utilizing the break time to open and log into the technological tools, recognizing that doing so during the regular lesson period would be time-consuming.” (20th November, 2023, Observation Field Note, Line Number: 83-85).

This issue of time constraints was presented before the validity committee members. Validity committee member 2 recommended that the researcher develop a technology integration timeline. This is what validity committee member 2 said:

“To address the time problem, review the entire lesson plan and calculate how many minutes each stage will take on average.” (VCM No. 2).

The technology integration timeline developed for the subsequent lessons outlined the steps, activities, time allocations, and duration of the entire lesson, providing a structured guide to be followed. After the development and utilization of the technology integration timeline, the issue of time constraints was never encountered again.

3.7.3. Excessive technology integration

In the observation field note recorded by the researcher after the first implementation, excessive technology integration was stated as one of the problems encountered. For context, in the first implementation, six technological tools, namely: a video, an animation, simulations from OLABS and PhET, Wordwall, and Kahoot, were

integrated. The researcher expressed that the integration of numerous technological tools disrupted the lesson's natural flow. This is what the researcher recorded:

"The issue of excessive technology integration emerged as a challenge during the lesson, marked by the integration of multiple technological tools within a short timeframe. The lesson integrated a video, an animation, simulations from OLABS and PhET, as well as Wordwall and Kahoot. The transition from one technological tool to another consumed valuable lesson time." (20th November, 2023, Observation Field Note, Line Number: 101-104).

The researcher has expressed that the issue of excessive technology integration and its effects were only realized after the lesson. Consequently, nothing was done during the lesson to solve it. However, in the observation field note recorded at the end of the first implementation, the researcher expressed that a plan has been devised to select and integrate only technological tools that align perfectly with the lesson's objectives in the subsequent lessons. According to the researcher, this will ensure that the students are not overwhelmed and that time will be managed efficiently. This is what the researcher recorded:

"Unfortunately, this problem was recognized post-lesson, preventing immediate remediation in the classroom setting. However, a plan has been devised to address this concern in subsequent lessons. The approach involves more deliberate selection of technological tools, ensuring their clear alignment with instructional objectives. The goal is to integrate the most relevant tools, incorporating at least one video, animation, simulation, and an online game. Additionally, for assessment purposes, the plan is to consolidate the games into a single platform, preferably Kahoot, given its popularity among the students. This strategic move aims to strike a balance, ensuring the effective use of technological tools without overwhelming the students and allowing for better time management to cover other essential aspects of the curriculum or lesson." (20th November, 2023, Observation Field Note, Line Number: 105-114).

During deliberations on the issue of excessive technology integration at the validity committee meetings, the validity committee members have provided various recommendations to address this issue. According to validity committee member 2, the aim of the study is to find an effective way of integrating technology into the lesson, not to integrate technological tools throughout the lesson. This is what validity committee member 2 said:

"We do not have to use technology at every stage of the lesson. We aim to integrate technology effectively, but it is not mandatory to use it at every stage of the course. I think you can use either Kahoot or Wordwall; you don't really need both." (VCM No. 2).

Additionally, validity committee member 3 also concurred with the view of validity committee member 2. According to validity committee member 3, it is not necessary to use too many animations and simulations. One or two simulations will suffice. This is what validity committee member 2 said:

“It is not necessary to include too many animations and simulations. Including one or two simulations would be enough.” (VCM No. 2).

In the subsequent implementations, the number of technological tools integrated into the lessons was drastically reduced. During the second implementation, only a video, an animation, a simulation, ESL Games Plus, and Kahoot were integrated. Moreover, in the third implementation, only an interactive video, a simulation, and Kahoot were integrated. According to the researcher’s post-implementation reflection journal recorded at the end of the third implementation, the lesson proceeded smoothly because fewer technological tools were integrated into the lesson compared to the previous lessons. This is what the researcher recorded:

“The lesson proceeded smoothly, and I was genuinely impressed by the positive impact that the integrated technological tools had on their understanding and enjoyment. I incorporated an interactive video, a 3D simulation, and Kahoot into the lesson. Unlike previous occasions, I didn't use a plethora of tools this time, as the ones integrated proved to be sufficient in aiding the achievement of the instructional objectives.” (Ankara, 4th December, 2023, Line Number: 2-6).

3.7.4. Contradictory questionnaire responses

During the validity committee meeting held after the second implementation, the validity committee members observed that some students had provided contradictory feedback on the questionnaire they filled out after the lesson. It was observed that two students did not give a high rating on the rating scale of the questionnaire, indicating some dissatisfaction. However, when it came to the written section of the questionnaire, where they were asked to elaborate on their ratings, the students unexpectedly gave positive responses, creating a contradiction in their overall feedback. For instance, when addressing the problems encountered during the lesson integrated with technological tools, Student 3 gave a rating of 4 on a scale of 1–10 (1 being very easy, 10 being very difficult). However, Student 3 wrote, “I didn’t have any problems; everything was really good.” Additionally, Student 3 provided a rating of 5 on a scale of 1–10 (1 being not effective at all, 10 being extremely effective) regarding technology’s contribution to

understanding of the lesson. In the elaboration, Student 3 recorded, “It was a little more interesting than our usual lesson.” The discrepancy was notable as, based on the elaboration, it was expected that the student should have given a higher rating, considering no problems were encountered and the integrated technological tools enhanced their understanding of the lesson.

This discrepancy in the students’ conflicting responses was realized by validity committee member 3. This validity committee member inquired why a student will assign 5 for a problem, when the said student also explained that he did not face any problem. This is what validity committee 5 said:

“In the questionnaire, some students gave 5 for difficulty, but why did they say 5? It means something was difficult, but we didn't know what that thing was. We didn't understand why they gave 5 because there was no other problem”. (VCM No. 2).

On the same issue, Student 7 provided a rating of 6 on a scale of 1–10 (1 being not effective at all, 10 being extremely effective) and expressed, “I think technology helped us. It was informative and, at the same time, funny. I understand all.” Yet still, Student 7 gave a rating of 6 on a scale of 1–10 (1 being not enjoyable at all, 10 being extremely enjoyable) for the enjoyment of the lesson with technology. Student 7 elaborated, “In my opinion, it was enjoyable. We have some games, such as Kahoot and Wordwall. It was funny.” Despite these positive comments, the ratings given by Student 7 were not as high as expected.

Considering these discrepancies, validity committee member 2, during the meeting, recommended that the researcher carefully review all students’ responses on the questionnaire before proceeding with interviews. This is what validity committee member 2 said:

“You're having an interview? Take a quick look at the questionnaire before the interview, and take a quick look at the questionnaire during the interview. You can explain a little more to the children in the interview. You can get some more information if you look at the results of the questionnaire before the interview”. (VCM No. 2).

The validity committee 2 member’s suggestion provided the researcher with the opportunity to delve deeper into the students' perspectives, allowing for more detailed responses and clarification on any inconsistencies in their feedback during the subsequent implementations.

3.7.5. Preference for computer peripheral functionality

During the implementations, some students expressed concerns regarding the functionality of the laptop mouse they were using. According to the students, the mouse's functionality made it difficult for them to use. These are what the students recorded in their questionnaire entries:

Student 4: *"There was a little problem with the computer, but I figured it out without any difficulties."* (Answer of Student 4 for the First Question of the Second Week's Questionnaire).

Student 6: *"The mousepad is a little hard to use on the laptop."* (Answer of Student 6 for the First Question of the Second Week's Questionnaire).

Student 8: *"The mouse on the computer didn't work that well and was hard to use, but other than that, there was no problem."* (Answer of Student 8 for the First Question of the First Week's Questionnaire).

Additionally, during the focus group interviews held after each implementation, the students reiterated the problems they had with the laptop's mouse. Here is what they said:

Student 4: *"The mouse didn't work as much as I liked when I tried to use it, but I kind of figured it out."* (Response of Student 4 During the Second Week's Focus Group Interview).

Student 6: *"I mean, I guess it's a really small problem, but it doesn't really matter. It's just the mousepad. Like it doesn't. Sometimes, when I try to move it, the cursor doesn't move. That's it."* (Response of Student 6 During the Second Week's Focus Group Interview).

Student 8: *"Like, the mouse was, erh, the mouse didn't work. It worked, but it was hard to use."* (Response of Student 8 During the First Week's Focus Group Interview).

During the focus group interview, the researcher probed further to find out whether the problem was resolved. From the interactions that transpired between the researcher and the students after the second implementation, it was revealed that the students only reported this problem to the researcher after the lesson. Consequently, nothing was done to address the issue and help the students. This is what transpired between the researcher and the students after the second implementation:

TEACHER: *Okay. So, Student 4, now with the problems you encountered during the lesson, you indicated that "there [was] a little problem with the computer, but I figured it out without any difficulties." What problem did you face?*

Student 4: *The mouse didn't work as much as I liked when I tried to use it, but I kind of figured it out.*

TEACHER: *Okay. Did you inform the teacher about this?*

Student 4: *No*

TEACHER: *So, how did you figure it out?*

Student 4: *I tried to use it a lot, and then it worked. Like it moved.*

TEACHER: *So, it worked perfectly in the end?*

Student 4: Yes.

TEACHER: Student 6, back to this question: the problem regarding the cursor not moving—did you bring this problem to the attention of the teacher?

Student 6: No.

TEACHER: No? So, has anything been done to solve this problem?

Student 6: No.

Despite not being informed about the problem during the lesson, when the researcher was informed about it after the lesson, the researcher investigated the problem. From the researcher's investigation, it was discovered that the problem was not a hardware malfunction but rather a matter of preference related to the speed of the mouse. This is what the researcher recorded in the observation protocols:

"The issue regarding the laptop mouse not functioning optimally was investigated. Upon investigation, it was determined that the problem stemmed from a setting related to the cursor speed. Subsequently, the speed of the cursor was adjusted to ensure it moved slightly faster than before, resolving the problem." (Observation Number 1, Date: 20th November, 2023).

"Upon investigating the issues reported by the students, it was discovered that the first problem was not related to a laptop malfunction as initially anticipated. Instead, it was a matter of preference regarding the mouse cursor movement speed. This feedback will be taken into consideration, and the necessary settings will be adjusted before the next implementation. As for the second problem, the student mentioned that it wasn't a significant issue, it was also about the cursor and he was able to resolve it on his own." (Observation Number 2, Date: 20th November, 2023).

3.7.6. Difficulty in assessing individual students' understanding

During the second and third validity committee meetings, members pointed out the issue of utilizing collaborative assessment instead of assessing individual student understanding. They emphasized that assessing students collaboratively makes it difficult to determine each student's individual comprehension. This is what Validity Committee Member 3 stated:

"During the assessment phase, you separated them into groups. I wonder if these groups held discussions before responding, or how did they proceed? When it comes to groups, sometimes a very good student in the group might dominate the discussion, and the other students do not provide any answers. As a result, the students who are smart or very hardworking answer almost immediately, while the other students remain silent. This makes it difficult to evaluate them accurately." (VCM No. 3).

The validity committee members suggested that individual assessment was necessary to accurately assess each student's understanding of the lesson. To address this,

validity committee member 2 recommended using Kahoot for individual assessments, allowing the students to participate individually using their mobile phones. The implementation of this strategy was proposed for subsequent lessons. This is what validity committee member 2 said:

“Why are you collaborating on the assessment? Because you said you use collaborative learning and social constructivism. But there is no constructivism here. This is teacher-centered education. Therefore, I recommend that you make an individual assessment here. Maybe you can do two separate things: an individual and a group assessment. Because we normally assess both individual performance and group performance in group work and cooperative learning, I think you can use Kahoot for individual assessment.” (VCM No. 2).

Provisions were made in the third lesson plan to use Kahoot to assess the individual understanding of the students. At the end of the third implementation, the individual understanding of the students was successfully assessed. This was made possible due to a model proposed by the validity committee member 2. Validity committee member 2 proposed that the “Bring Your Tablet” model be implemented in which the students and their parents are informed in advance to bring their tablets or smartphones to schools for a lesson. This is what the validity committee member 2 stated:

“There is a “Bring Your Tablet” program abroad, especially in Europe and America. Students are informed beforehand to bring their tablet devices to class. It is explained that technology will be used in class that week, and they will need to bring their tablets to the classroom. We need to implement this model, ensuring that every student brings their device to class.” (VCM No. 3).

During the third implementation, Kahoot was utilized to assess the individual understanding of students. Among the benefits of individually assessing students was the researcher's ability to personally evaluate each student's understanding, as well as identify individual strengths and areas needing improvement in their comprehension.

In the post-implementation reflection journal recorded at the end of the third implementation, the researcher noted that students' individual understanding was assessed using their phones with the help of Kahoot. Here is what the researcher recorded:

“At the end of the lesson, I employed Kahoot to assess the individual understanding of the students regarding the lesson. Each student completed the Kahoot quiz independently using their smartphones. From my observation, this turned out to be the most enjoyable segment of the lesson for the students.” (Ankara, 4th December, 2023, Line Number: 23-26).

4. CONCLUSION, DISCUSSION AND RECOMMENDATIONS

In this chapter, the study's findings are consolidated to address the research questions, followed by a thorough discussion of the results in the context of relevant literature. Additionally, theoretical dimensions, methodological considerations, and the implications of the findings are explored, along with recommendations for future research endeavours in this domain.

4.1. Conclusion

Numerous studies have explored the significance of integrating technology into the teaching and learning process. Consequently, findings from these studies have elucidated the multitude of benefits that both teachers and students derive when technologies are integrated into education. It has been shown that integrating technological tools and equipment into teaching processes, especially in science education, encourages students to actively participate in learning science and deepens their comprehension of the nature of science and inquiry (Fakherji, 2019). Additionally, it has been connected to strengthening students' capacity for active knowledge construction and problem-solving (Trowbridge, Bybee, & Powell, 2008).

Effective integration of technology into instruction hinges on various factors. These include access to available technologies, time allocation, instructors' beliefs and attitudes toward technology, the availability of technical support, instructors' confidence, knowledge, and skills, as well as ongoing professional development. These elements are crucial, as their absence can impede the seamless integration of technology into the instructional process. Conversely, considerations such as the selection of appropriate technological tools to enhance student learning, students' perceptions of technology, the adaptation of lesson plans to accommodate technological tools, the identification of potential challenges, and strategies to mitigate them are vital. This study seeks to address these pertinent issues concerning the integration of technology into the science teaching and learning process.

The primary objective of this action research was to investigate effective methods of integrating technology into the science teaching and learning process. Accordingly, science lessons covering topics such as forces and motion, speed, and describing movement were conducted with the support of various technological tools. The study was conducted during the first semester of the 2023–2024 academic year at the International

Gokkusagi Schools in Ankara. It involved 7th-grade students, with a total of eight participants, comprising four males and four females. All the students actively participated in the implementation. The researcher assumed a dual role, acting as both a researcher and a science teacher. The implementation phase spanned three weeks, during which various forms of data were collected both before, during, and after the implementation.

Prior to implementation, the researcher developed a science lesson plan comprising eighty minutes, equivalent to two lesson periods, integrating various technological tools. Additionally, a technology integration timeline was crafted by the researcher to provide guidance on the incorporation of technological tools into the lesson, specifying the timing and duration for each tool. Subsequently, the researcher documented a pre-implementation reflection journal outlining the implementation process, the selected technological tools, their sources, anticipated challenges, and strategies for addressing them. Finally, a meeting was convened with the validity committee members to review the lesson plan and the proposed technological tools for integration. During these meetings, the suitability of the technologies for the students' level and the topic were scrutinized. Implementation proceeded only after receiving approval from the validity committee members.

During the implementation, the science lesson, integrated with various technological tools, was delivered to the students following the guidance of the lesson plan and the technology integration timeline. Throughout the lesson, a range of technological tools were utilized, including interactive videos, animations, 2D/3D simulations, ESL Game Plus, Wordwall, and Kahoot, alongside technological devices such as smartboards, smartphones, and laptops. Following the lesson, diverse forms of data were gathered from the students to evaluate the implementation. Data collection instruments utilized at this phase included a questionnaire administered to gather insights into any problems encountered during the lesson and the contribution of technology to their understanding and enjoyment. Additionally, the students were prompted to write reflection journals, detailing their experiences during the lesson. Furthermore, a focused group interview was conducted with the students to uncover their perspectives on the implementation and integration of technology into the science teaching and learning process. In parallel, the researcher also collected data from himself, which included an observation protocol utilized to document both descriptive and reflective notes on the

lesson's events. Furthermore, an observation field note was maintained, capturing detailed records of all occurrences during the lesson. Finally, the researcher penned a post-implementation reflection journal, elaborating on personal experiences during the lesson.

At the end of the implementation, meetings were convened with the validity committee members. During these meetings, the researcher presented the data collected from the lesson for a macro-level analysis, facilitating a discussion on the overall progress and effectiveness of the lesson. However, particular emphasis was placed on identifying and addressing any problems encountered, with the validity committee members collaboratively seeking solutions. Subsequently, the lesson plan and the technological tools intended for the subsequent lesson were scrutinized to ensure their appropriateness for the students' level and the topic to be taught. All decisions and meeting proceedings were meticulously recorded by the researcher and later subjected to micro-level analysis along with other collected data. Both inductive and deductive data analysis methods were employed, with an inductive thematic approach to analyzing the data. The conclusion obtained to address the research questions of the study are detailed below:

4.1.1. Conclusions regarding the technologies that were used to improve students' understanding of key science concepts at the beginning, during, and at the end of the implementation week's courses in this study.

Throughout the lesson, various technological tools were integrated to enhance the students' understanding of scientific concepts. Interactive videos, animations, simulations, ESL Game Plus, Wordwall, Kahoot, and technological devices such as smartboards, smartphones, and laptops were utilized. These tools were integrated at different stages: videos and animations at the beginning, 2D/3D simulations in the middle, and ESL Game Plus, Wordwall, and Kahoot at the end. The rationale was to investigate their effective utilization and contribution to learning. This approach spanned the three-week implementation period. Interactive elements engaged the students from the outset, simulations provided hands-on exploration, and gamified activities promoted assessment. Such integration aimed to foster active participation and deepen understanding.

Comprehension, as defined in Bloom's taxonomy of cognitive objectives and later modified to understanding in the revised taxonomy by Anderson and Krathwohl (2001), entails making sense of recalled information and its application in other cognitive processes. In this revised taxonomy, understanding encompasses interpreting,

exemplifying, classifying, summarizing, inferring, comparing, and explaining, as outlined by Ornstein and Hunkins (2018). This understanding of key science concepts, also known as scientific understanding, according to Grimm (2017), Khalifa (2017), and Strevens (2013), should be rooted in objective scientific explanations or knowledge, such as causal relations. The students' understanding of these concepts is assessed through their ability to utilize technology for tasks like completing 2D/3D simulations and utilizing platforms like ESL Game Plus, Wordwall, and Kahoot for assessment. Additionally, their engagement with technology and peers, collaborative efforts, and demeanour during instruction contribute to evaluating their understanding of key science concepts.

It was clear from the researcher's extensive observations made during the lesson that the integration of technology to augment the scientific lesson had greatly improved the students' understanding of key science concepts. The students engaged and enthusiastically participated in all of the activities, which included coding tasks, interactive videos, simulations, and assessments utilizing Wordwall and Kahoot. Their active participation with the content on smartphones, laptops, and smartboards demonstrated their understanding of the subject matter in addition to their enjoyment of it. The students' learning was further reinforced through collaborative projects, where they had to work together to solve problems and share ideas. Because the technological tools were interactive, there were chances for questions and answers, which made sure that everyone understood the material effectively. Furthermore, the students' positive responses to the activities—which were conveyed through their remarks, facial expressions, and requests for more interactive classes—highlighted how successful the integrated technological tools were in creating an enjoyable and interactive environment for learning. All things considered, the researcher's findings demonstrated how important technology is for raising the understanding of science concepts, encouraging participation, and developing an engaging learning environment.

The reflections from the students' reflection journals following the integration of various technological tools into their science lessons provided compelling evidence of the effectiveness of such methods in enhancing their understanding of key scientific concepts. By employing interactive videos, animations, games, simulations in both 2D and 3D, and platforms such as Kahoot, the students were able to improve their understanding of scientific concepts while also finding the learning process enjoyable and engaging. The students' active engagement and focus were enhanced by the interactive nature of the

integrated technology tools, which allowed them to collaborate on simulations, pause videos to answer questions, and compete in Kahoot quizzes. The students consistently expressed their excitement for these exercises, praising them for making learning enjoyable and understandable. The integration of technological tools allowed for possibilities for hands-on learning and instant feedback, in addition to helping the students visualize abstract concepts. Overall, the students' reactions were overwhelmingly favourable, confirming the benefits of using technology in scientific lessons to promote deeper understanding, increase engagement, and make learning enjoyable.

The questionnaire responses from the students clearly demonstrated the positive impact of technology on improving their understanding of key scientific concepts. In all of their responses, the students repeatedly emphasized how technological tools—including interactive videos, simulations, animations, and educational games like Kahoot—helped them understand the science lessons. By simulating actual laboratory experiments and making difficult topics easily visualized, these technological tools offered realistic examples, explanations, and opportunities for hands-on learning. The students' learning was made more engaging and enjoyable by the participatory aspect of these exercises, which promoted an improved understanding of areas like mathematical calculations and graphical representations. In addition, the collaborative tasks and the interactive assessments were some of the activities involving technology in the classroom that improved the students' learning and reinforced their knowledge through practice. The students generally agreed that technology played a major role in enhancing their understanding of science topics and boosting the effectiveness, accessibility, and enjoyment of science lessons. As a result, incorporating technology into scientific education was essential to providing enjoyable and engaging learning opportunities for the students.

Following the science lesson integrated with various technological tools, the students' interview responses provided insights into how well they understood important science concepts. During the interview, the students emphasized the use of several technological tools, including Wordwall, Kahoot, animations, and videos, all of which were thoughtfully integrated at various points of the lesson. These technological tools were well received, as seen by the overwhelming majority of their responses, which linked them to improved understanding, higher levels of engagement, and enjoyment. The students expressed how interactive tasks like Kahoot encouraged their participation and

knowledge retention, while animations and simulations helped them visualize abstract concepts. In addition, the students reported improvements in their performance and grades, attributing this to the efficiency of these technological tools in facilitating understanding and problem-solving. All the students agreed that utilizing technology in the classroom has improved their educational experience by making the lessons more engaging, understandable, and enjoyable. Consequently, the information gleaned from their views clearly suggested that technology should be used and explored further to help students better understand important science topics and, in the process, create a more productive and engaging learning environment.

The researcher's observations, students' reflection journals, questionnaire responses, and interview responses were combined to provide insights that demonstrated the unquestionable benefit of technology in improving students' understanding of key scientific concepts. A recurring narrative surfaced from all of the sources: the students' learning experiences have been substantially enhanced by the thoughtful use of technological tools like interactive videos, simulations, animations, and educational games like Kahoot. The science lessons were eventually more understood and enjoyable as a consequence of these technological tools' engagement, encouragement of collaboration, and provision of opportunities for hands-on learning. The students' favourable reactions and passionate participation—which were demonstrated by their comments, expressions, and requests for additional interactive sessions—further confirmed that the integrated technological tools effectively created an engaging and productive learning environment. The students' perceptions of the noticeable improvements in their grades and performance further highlighted the useful advantages of integrating technology into scientific instruction. The overwhelming weight of evidence points to the need for ongoing research and application of technology to improve science concepts learned by students. This will foster student engagement, active learning, and enjoyment in the classroom.

4.1.2. Conclusions regarding the students' views on technology-supported science lesson activities.

Throughout the three-week implementation of science lessons integrated with various technological tools, the students expressed a diverse range of views, insights, and preferences about the integrated technological tools. This comprehensive understanding was facilitated by the utilization of multiple data collection instruments, including reflection journals, questionnaires, and semi-structured focus group interviews.

The student journals' remarks clearly showed how well they received the technology-enhanced scientific instructional activities. From all reports, the students' views were largely positive and enthusiastic. The students pointed out how much they enjoyed using technological tools and equipment, including 3D simulations, interactive videos, and educational games like Kahoot. These resources not only improved their understanding of scientific concepts but also promoted an active and enjoyable learning environment. In particular, the utilization of simulations was found to be a good way to conceptualize abstract topics; also, collaborative tasks and gaming enhanced their educational experience. The students considered technology integration to be both interesting and helpful in retaining and comprehending scientific concepts. This was the unanimous opinion of the class. Therefore, the data from their reflection journals clearly supported the use of technology in scientific classes going forward, pointing out how successful it was in making learning enjoyable and engaging.

The students' responses to the questionnaire revealed a clear consensus regarding their views on technology-supported science lesson activities. Due to the fact that these kinds of activities were enjoyable and engaging, they were largely preferred by the students. The students emphasized that the use of interactive resources like Kahoot, games, and simulations was very advantageous as it increased learning enjoyment and promoted comprehension. Additionally, collaborating in groups and working as a team further increased the enjoyment and effectiveness of these activities. Remarkably, the students expressed that they would prefer to use technology in the classroom more often, especially with apps like Kahoot. In general, technology was viewed as an invaluable tool for improving educational opportunities, dispelling ambiguities, offering good illustrations, and ensuring that classes were enjoyable and effective.

It was clear that technology-supported scientific activities had a positive impact on the students' learning experiences based on the views that they shared throughout the

interview. The technology-supported science lesson activities were thought to be engaging, enjoyable, and effective in helping the students' understanding of the scientific concepts. Along with improving their understanding of scientific subjects, the use of simulations, animations, videos, and online learning communities such as Kahoot also helped the students have fun and collaborate among themselves during task executions. Especially when compared to more conventional approaches like learning only from textbooks, the students thought that the integrated technological tools improved their knowledge, enhanced their enjoyment of the scientific lessons, and allowed for deeper understanding. These exercises' collaborative and interactive elements encouraged the students to actively participate and let them learn in a way that suited their preferences. Overall, the overwhelmingly positive feedback underscored the necessity of incorporating technology-assisted activities into scientific classes to create a more enjoyable and productive learning environment.

The conclusion that technology-assisted scientific instructional activities have had a significantly favourable influence on the students' learning experiences was strongly confirmed by the data collected from the students' reflection journals, questionnaires, and interviews. The students were enthusiastic and positive about using technological tools like interactive videos, 3D simulations, and educational games like Kahoot. It was discovered that these technological tools not only enhanced the students' understanding of scientific concepts but also promoted an engaging and enjoyable learning environment. All the students agreed that integrating technology into the classroom was helpful and exciting and that it increased their engagement, comprehension, and peer cooperation. The students also expressed a desire for more frequent use of technology, especially with interesting apps like Kahoot, and particularly appreciated the collaborative nature of these activities. All things considered, the data showed how important technology was for improving learning activities, clearing up misconceptions, and making science lessons effective and enjoyable. It was also evident from this that, to create stimulating and effective learning environments in the future, it is imperative to keep integrating technology-supported activities into scientific education.

4.1.3. Conclusions regarding how the lesson plans were organized with technology integration in the science lesson.

At the implementation stage of this study, careful consideration was given to the design and delivery of the science lessons, integrating a diverse array of technological tools. Three detailed lesson plans, each designed to meet specific learning objectives over three weeks, were meticulously developed to aid in this process. The lesson plans were designed to ensure that the technological tools were strategically placed in accordance with the science curriculum's progression and content. Various technological tools were employed over the three-week implementation period to improve student engagement, enjoyment, and understanding of key science concepts. These technological tools included Wordwall, Kahoot, ESL Game Plus, interactive videos, animations, and 2D and 3D simulations. The seamless integration of these technologies into the science lesson was accomplished by placing them at critical points—the beginning, middle, and end of each lesson.

The technological tools integrated into the science lesson to enhance students' engagement, understanding, and enjoyment were sourced from various platforms. The interactive video was sourced from YouTube and offered a lively presentation of scientific concepts with visual aids. In order to support the instructional content, provide visual reinforcement, and provide a step-by-step explanation of how to complete subsequent simulation tasks, animations were also sourced from YouTube and OLABS. The researcher developed a 3D simulation that closely matched the lesson's objectives and was made possible via CoSpacesEdu. Wordwall and Kahoot were used for assessment, while ESL Game Plus offered engaging activities to reinforce concepts for interactive gaming experiences.

It was clear from the lesson plans and the recorded observation protocols of the science lesson that deliberate planning and thoughtful integration of technological tools were utilized to improve the learning process. Different strategies were employed at the beginning of the lessons to get the students interested and provide them with visual explanations of the subjects being covered. These featured interactive question-and-answer sessions with Cambridge Lower Secondary Science Stage 8 software, as well as the presentation of videos and animations on smartboards. By giving clear and succinct explanations, these introductory exercises helped the students understand the instructional objectives and set up the foundation for the instruction. Additionally, the use of

multimedia elements in the videos promoted the students' engagement through active participation, with understanding reinforced by discussions that followed pauses for calculations. Overall, the methodical integration of technology at the beginning of the science lessons created a lively and engaging learning environment and ensured that the students were actively engaged in exploring and understanding the scientific concepts.

Throughout the lesson, it was evident that the lesson plans with technological integration were organized and carried out seamlessly and efficiently. Throughout the middle of the lesson, a variety of technological tools were strategically employed to improve the learning process, including animations, 2D simulations from OLABS and PhET, and 3D simulations. These tools were utilized to engage the students in practical tasks, such as conducting experiments and calculating speed, distance, and time, as well as to demonstrate scientific concepts, such as Newton's Third Law of Motion. Through their active participation in these exercises, the students expressed that they understood and could apply the concepts that had been presented. All things considered, the use of technology in the lesson plans effectively enabled interactive and immersive learning experiences, enabling the students to understand difficult scientific concepts more easily.

A range of technological tools were seamlessly integrated to assess the students' understanding and reinforce their learning at the end of each lesson. To be more precise, interactive games like Wordwall, ESL Games Plus, and Kahoot were utilized to get the students involved in both group and individual assessment tasks. With the help of these interactive and dynamic platforms for comprehension assessment, the students were able to actively engage and demonstrate that they understood the material covered in the lesson. Specifically, Kahoot was used as an extensive assessment tool that covered a variety of subjects treated in the lesson. Overall, the students' learning experiences were made more dynamic and successful by the use of these technological tools in the lesson plans, which helped them retain and comprehend scientific concepts on a deeper level.

The lesson plans that were organized to utilize technology at the beginning, middle, and end of science lessons demonstrated a methodical and efficient way to improve the students' learning. The students' attention was initially piqued by the methodical planning and seamless integration of technology, which included multimedia components, interactive Q&A sessions, and visual explanations. These foundational activities provided a clear understanding of the learning objectives and established a strong basis for further instruction. In the middle phase of the lesson, a wide range of technological tools, such

as simulations and animations, enabled hands-on tasks and conceptual explanations, enabling the students to actively participate in the instructional process. The seamless integration of technological tools enabled engaging and immersive educational experiences, augmenting the students' understanding of intricate concepts in science. Ultimately, the smooth integration of interactive games such as Wordwall, ESL Games Plus, and Kahoot provided dynamic platforms for assessment at the end of each lesson, enabling the students to participate actively and demonstrate their understanding. Overall, the lesson plans' systematic organization and thoughtful utilization of technological tools created a vibrant and stimulating learning environment that helped the students retain and comprehend scientific concepts at a deeper level.

4.1.4. Conclusions regarding the problems encountered in the process of integrating technology into science lessons and their solutions.

The integration of various technological tools into the science lesson encountered minor challenges, prompting strategic decisions to address them to ensure a seamless integration and lesson. This study utilized an array of data-collection tools to identify and address these problems. These tools made it easier to identify problems that arose during the lesson and to document the methods used to address them. Real-time observations of problems as they emerged were recorded via the researcher's observation protocol. Furthermore, semi-structured interviews and questionnaires allowed the students to express their views and draw attention to any problems they had. Further insights and observations on the problems encountered and the approaches used to overcome them were recorded in the researcher's post-implementation reflection journal. All of these techniques for gathering data helped to improve the integration of technology tools into science lessons by providing an in-depth understanding of the process and enabling informed decision-making.

The process of integrating technology into the science lessons presented several challenges, each requiring a tailored solution for effective resolution. The investigation into cursor speed settings and subsequent performance optimization was prompted by initial concerns about the laptop mouse's functionality. The students' preferences for the pace at which the cursor moved were also documented, and they were taken into account when making adjustments. Notwithstanding these small challenges, the lesson progressed smoothly, and no major issues emerged. However, major problems like time constraints,

techno-centric distractions, and excessive integration of technological tools required further strategic responses. Time-sensitive adjustments were implemented to optimize setup processes during break times, ensuring the efficient utilization of instructional time. Redirecting the students' attention toward the lesson and minimizing the number of active windows helped to reduce techno-centric distractions. Furthermore, plans were also developed to streamline assessment platforms and improve technological tool selections in order to maximize learning opportunities without overburdening the students. Despite these challenges, the integration of technology into the science lessons proved successful.

It was clear from the responses obtained from the questionnaire administered to the students at the end of the lesson that, despite a few minor problems, the integration process was generally effective. The students identified technological issues, such as malfunctioning computer peripherals like computer mice or touchpads, as the biggest problem. But these problems were quickly handled, either by the students themselves or with little assistance from the teacher. One student also brought out the difficulty of another student responding too quickly during the Kahoot session, which resulted in them getting an answer wrong and losing some points, which had little effect on the lesson's pace. However, this challenge did not hinder the integration process's overall effectiveness. Rapid fixes were put into practice, such as resolving technological issues and moderating student involvement to ensure equitable participation. Most importantly, most of the students reported that there were no major problems and that the lesson was easy to understand and enjoyable. Overall, despite a few little challenges, proactive approaches and flexibility made sure that the technology integration into the science lesson went smoothly and successfully.

The majority of the students did not experience major problems, based on the responses given during the interview session that was conducted after the lesson. A small number of the students did, however, notice some minor problems, mostly with the computer's mouse or cursor functionality. Even with these problems, the majority of the students were able to overcome them on their own without asking the teacher for help. Unfortunately, these specific problems were not explicitly brought to the teacher's notice, and as a result, no concrete steps were taken to address them. All the students, however, seemed to agree on one thing: the technological integration was well received, and most of them expressed that they had an easy time studying without any serious technical

difficulties. As a result, even when a few minor technical issues occurred, the technology-supported science lesson progressed well.

According to the researcher's post-implementation reflection journal entries, there were challenges with integrating technology into the science lessons, including time constraints, distracted students, and overuse of technology. Proactive strategies such as effective time management, reducing distractions, and re-evaluating the strategy for upcoming lessons were used to overcome these challenges. Although there were no problems during the last implementation, the validity committee members assisted the researcher in resolving tool selection challenges, as the selection of technological tools for the third week's implementation became harder because of the nature of the topic. Errors in the questionnaire responses made by the students were discovered and quickly fixed after implementation, underscoring the significance of providing clear feedback.

There were several challenges to overcome when incorporating technology into the science lessons, ranging from minor ones like cursor speed adjustments to major ones like time constraints and techno-centric distractions. However, proactive approaches that were customized for every difficulty ensured that technology-enhanced instruction was implemented successfully. While measures to reduce distractions, simplify tool selection, and decrease the number of tools utilized in one week were put into place to improve learning experiences, quick reactions to technical issues and adjustments during break periods maximized instructional efficiency. The majority of the students expressed satisfaction with the technological integration, despite a few minor technical difficulties, and many thought that the lessons were easy to understand and engaging. The researcher's reflection journal entries emphasized the value of adaptable strategies and proactive problem-solving while overcoming challenges related to technology integration. Overall, despite certain difficulties, thoughtful solutions and the students' input highlighted how well science lessons can use technology to create successful, engaging, and enjoyable learning environments.

To combine all these separate conclusions of each data collection instrument, it can be summarized that the science teacher, acting as a researcher, developed his teaching practice throughout the three weeks of implementation regarding the effective integration of technology into science courses. The actions, in the form of lesson plans, were developed and implemented. The students enjoyed the science courses with ICTs, which facilitated easier learning for them.

4.2. Discussion

In this section, the research findings are discussed in light of relevant literature regarding technology integration into science education. The discussions are conducted based on the research questions, which include discussions regarding the technology that can be used to enhance the students' understanding of key science concepts, discussions regarding the students' perspectives on technology-supported science lesson activities, discussions concerning how lesson plans were organized with technology integration in science lessons, and discussions addressing the problems encountered in the process of integrating technology into science lessons and their respective solutions.

4.2.1. Discussions regarding the technologies that were used to improve students' understanding of key science concepts at the beginning, during, and at the end of the implementation week's courses in this study.

In this study, various technological tools were integrated into the science teaching and learning process. These tools included interactive videos, animations, 2D/3D simulations, ESL Game Plus, Wordwall, and Kahoot. The findings from this study revealed that these technological tools greatly contributed to the students' understanding of key science concepts. The views expressed by the students on how the simulation tasks they had completed made the science lesson easier, more understandable, and enjoyable were consistent with the findings of Wieman, Adams, Loeblein, and Perkins (2010). They contend that simulations are great instructional aids that help students understand abstract concepts that are sometimes challenging for them to understand. Furthermore, they mentioned that simulations may be used in a variety of learning environments, such as lectures, homework, individually or in small group inquiry assignments, and laboratories, much like how the students in this study worked collaboratively to complete the simulation tasks. These authors have also found that PhET simulations, which were one of the simulations included in the study, are highly effective teaching and learning instruments for science. According to Damassa and Sitko (2010), simulation technologies are useful instructional tools that are being used more frequently because of how well they can produce impactful learning experiences. Additionally, the students utilized 3D simulations during the current study. They expressed that the 3D simulations helped them understand the concepts well and allowed them to see the experiments as if they were in the real world. Elangovan and Ismail (2014) reported similar findings, where 3D

simulations used during a biology lesson improved students' understanding, performance, and achievement.

The use of interactive videos, sourced from online sites such as YouTube, within this study has become an effective pedagogical approach. By offering dynamic visual and auditory elements that attract the students' attention and improve their understanding of complex scientific concepts, these videos supported conventional teaching approaches. According to research by Sherer and Shea (2011), as students are more likely to be drawn to multimedia content than traditional instructional materials, the integration of YouTube videos in the learning process encourages active participation from students. Additionally, the interactive nature of these videos promotes students' participation in the classroom by encouraging discussion, engagement, and cooperation. Students utilize YouTube videos for science learning for a number of reasons, and a lot of these have to do with their agency over the way that the material is delivered. For instance, many students emphasize that having the option to pause, rewind, or advance lets them work at their own speed and concentrate on the areas where they need help the most (Stockwell et al., 2015). Breslyn and Green (2022) further suggest that educational videos on YouTube may be used to enhance science education for students. Additionally, they give students the chance to study under subject-matter specialists with a variety of backgrounds and pedagogical approaches. Furthermore, research by Jones and Cuthrell (2011) has demonstrated the advantages of incorporating YouTube videos into the classroom concerning the achievement of students. These videos accommodate a variety of learning preferences by appealingly presenting lesson content, which helps students retain and understand important topics on a deeper level. Additionally, instructors may easily add current and relevant information to their lessons, thereby improving the learning experience for students, thanks to the accessibility and ubiquity of online video platforms.

Throughout the implementation of this study, animation emerged as a valuable technological resource utilized to present abstract concepts to the students at the outset of the lessons, laying the groundwork for subsequent instructional activities. Researchers like Barak and Ashkar (2011) attest to the fact that the animations utilized in the lessons successfully accomplished their intended goal. These researchers observe that animations have the ability to clarify ideas that are fundamentally abstract and difficult to understand, facilitating the shift from abstract to concrete thought. Animations help students build a solid understanding and increase their engagement throughout instruction by

accomplishing this. Ikwuka et al. (2017) also stress the value of animation in educational settings, especially when it comes to illustrating procedures that could be hard or impossible to describe in conventional ways. Like Burn (2013), they claim that animations are now indispensable tools for enhancing students' understanding of scientific concepts. Burn argues that animation is essential to the creation and dissemination of scientific knowledge because it is a fundamental tool in the kineikonic mode of the moving image.

Because game-based learning is more successful than traditional learning approaches, it is becoming more and more popular in educational settings. Games are used in this active learning strategy to improve the educational opportunities for students. Several studies, such as Ismail et al. (2019), have documented several advantages linked to the incorporation of game-based applications in comparison to conventional techniques. Games such as ESL Games Plus, Wordwall, and Kahoot were integrated into the science lesson during the implementation phase of this study, aligning with the findings of Chaiyo & Nokham (2017), Licorish et al. (2018), and Omar (2017). The researchers observed the increasing trend of incorporating interactive game-based applications into educational settings, highlighting their capacity to establish relevant technology-enhanced teaching methodologies and boost students' overall learning experiences, motivation, and engagement.

Kahoot, specifically, was utilized during the assessment phase of the lesson to assess the students' understanding, enhance enjoyment, and improve academic performance. The students expressed appreciation for Kahoot and consistently requested instructional activities integrated with it due to its effectiveness in enhancing their learning experiences. This perspective aligns with the research conducted by Mdlalose, Ramaila, and Ramnarain (2022), which revealed that Kahoot! significantly improve students' academic achievement, motivation, and engagement during science lessons. Additionally, the findings of the current study are consistent with research by Sabandar, Supit, and Suryana (2018), which emphasized Kahoot's capacity to support students in meeting learning objectives, boosting motivation, and taking part in an enjoyable learning process. Further evidence for Kahoot's advantages comes from studies conducted by Arif, Zubir, Mohamad, and Yunus (2019) and Nadeem & Al Falig (2020), which show how it can help students relate to lessons better, remember key ideas, discover new content, improve retention, and give teachers and students immediate feedback on their progress.

Undoubtedly, the integration of technological tools into the lesson has significantly contributed to achieving this study's objectives, which aimed to enhance students' understanding of key science concepts while also making the lesson more enjoyable. The students themselves have expressed appreciation for the integrated technological tools utilized in the lesson, noting their positive impact on their comprehension of key science concepts. This appreciation is evident from the responses provided in their reflection journals, questionnaires, and during the interview sessions. Among all the integrated technological tools, the students have particularly shown enthusiasm for the 3D simulation developed on the CoSpacesEdu platform and Kahoot. These tools stand out due to their interactive and engaging nature, which has undoubtedly enriched the learning experience for the students.

4.2.2. Discussions regarding the students' views on technology-supported science lesson activities

Throughout the three-week implementation of science lessons integrated with various technological tools, the students have conveyed a diverse range of views, insights, and preferences regarding the tools integrated into the science teaching and learning process. Predominantly, the students have expressed positive and enthusiastic views about the technological tools utilized, highlighting their enjoyment of the interactive elements such as 2D and 3D simulations, interactive videos, and educational games like Kahoot. They have emphasized that these integrated technological tools not only enhanced their understanding of scientific concepts but also fostered an active and enjoyable learning environment. These sentiments align with findings by Carter, Greenberg, & Walker (2017), who observed that students perceive technology as a means to enjoyable learning experiences, increased confidence, enhanced skills, affordability, improved academic performance, and avoidance of boredom or difficulty, as well as time-saving.

The students have also conveyed positive perceptions regarding the interactive videos integrated into the lesson. They have specifically highlighted the interactive nature of these videos in fostering engagement, enhancing the enjoyment of the lesson, contributing to their understanding of concepts, and aiding in the visualization of complex ideas. The students described how the videos were utilized during the lesson, mentioning that they watched the video, paused it at certain points to answer questions, and found this interactive approach to be both enjoyable and beneficial for their understanding.

These views were consistent with findings from the study conducted by Gedera and Zalipour (2018), in which students expressed positive perceptions towards the use of videos in teaching and learning. The students find videos engaging and helpful for understanding concepts, and they appreciate their accessibility to a variety of ideas and projects beyond academic articles. Additionally, the students in this current study expressed that they prefer learning through videos over reading academically written materials, as videos generate interest in the subject matter and facilitate content revision. Furthermore, the students highlighted how the interactive nature of the videos facilitated collaborative work on tasks, thereby enhancing classroom discourse. This finding also aligns with the study carried out by Jackman and Roberts (2014), in which students expressed an improvement in in-class discourse following the viewing of videos, demonstrating the immediate impact of videos on classroom learning.

The students emphasized the significant role played by the animations integrated into the lesson in expanding their understanding of the mathematical calculations involved in the science lesson. Moreover, they expressed that the combination of animations and simulations contributed to making the lesson more accessible and comprehensible, allowing them to visualize experiments effectively. Additionally, they found these multimedia elements to enhance the overall enjoyment of the lesson. Similar sentiments were echoed in the study conducted by Yasak Cevizci and Kerimgil Çelik (2023), where students expressed a strong preference for lessons integrated with animations, finding them enjoyable, unique, and engaging. They believed that these animated lessons facilitated better retention of new information. Furthermore, Öztürk's study (2014) also reported students' positive feedback on the integration of animations into lessons, with students affirming that it made learning enjoyable, effective, and aligned with the instructional goals.

The integration of 2D and 3D simulations into the science lesson was met with positive feedback from the students, who described the simulation tasks as enjoyable, interesting, and beneficial for their understanding of the lesson. This sentiment is consistent with findings from a study conducted by Koyunlu Ünlü and Dökme (2015), where students similarly expressed that computer simulations enhanced the enjoyment and fun factor of their science classes. They noted that the lessons became more captivating and held their interest to a greater extent compared to traditional science classes. Additionally, students in the study by Csizer and Kormos (2009) shared similar

perspectives, describing simulation activities as enjoyable, interesting, challenging, and dynamic, thereby enhancing the overall engagement in their lessons.

Furthermore, the students in the current study expressed a strong preference for Kahoot as an integral part of the science lesson, noting that it enhanced their enjoyment of the lesson and facilitated better understanding. They expressed a desire for more science lessons integrated with Kahoot, highlighting the motivational impact it had on their engagement and participation in the lesson. These sentiments were consistent with findings from a study conducted by Putra, Suseno, and Setiadi (2022), where students similarly reported that Kahoot added an element of enjoyment to the lesson and contributed to high levels of motivation, attention, and enthusiasm during the lesson.

The students in the current study expressed a deep appreciation for the technological tools integrated into their learning experience, particularly highlighting the collaborative activities facilitated by these tools. They emphasized how the collaborative nature of their lessons not only enhanced enjoyment but also promoted active participation, allowing them to scaffold their learning with support from their peers. These sentiments echo findings from a study by Ahern et al. (2016), which explored student perspectives on technology integration in education. The researchers observed that students, irrespective of their geographical locations, engaged in collaborative educational endeavours facilitated by technology, fostering active involvement in their learning. Furthermore, students in Ahern et al.'s study expressed a shared sentiment regarding the enjoyable nature of technology-integrated lessons and the promotion of active participation, reflecting the views expressed by participants in the current study. These findings underscore the transformative role of technology in education, facilitating collaborative learning experiences that promote engagement and active involvement among students.

In summary, the students have overwhelmingly expressed positive views and excitement regarding the integration of technology into science education. They reported that the integration of technological tools enhanced their academic performance, deepened their understanding of science concepts, and made lessons more enjoyable and engaging. Moreover, the students appreciated how technology allowed them to visualize abstract concepts and facilitated collaborative learning experiences. These findings align with the research conducted by Pittas and Adenike (2019), which similarly highlighted

students' perceptions of technology integration leading to improved learning outcomes, enhanced enjoyment, easier comprehension, and increased fun in lessons.

4.2.3. Discussions regarding how the lesson plans are organized with technology integration in the science lesson.

During the implementation, the lesson plans employed to deliver the science lessons integrated with various technological tools were meticulously organized to accommodate the seamless integration of these tools. Several crucial factors were considered in the development and organization of these plans to ensure a smooth integration process. Among these factors were the identification of the lesson's unit and topic, determining the lesson duration, selecting the appropriate coursebook, defining clear learning objectives, assessing the students' relevant prior knowledge, and selecting suitable teaching and learning strategies, methods, and techniques. Additionally, careful consideration was given to the selection and integration of technological tools, understanding the teaching and learning context or procedure, and utilizing supplementary resources such as workbooks and worksheets. The systematic organization of these components within the lesson plans greatly facilitated the seamless integration of technological tools, contributing to the effectiveness of the lessons.

There are a number of technological tools that may be integrated into a lesson, but the primary determinant of whether or not they are integrated is the instructional goals that are established for the lesson. Technological tools that best support students' understanding of the lesson and the accomplishment of instructional objectives are given priority during the selection process. This strategy is in line with the insights of Hutchison and Woodward (2018), who stress the vital role that technology plays in advancing educational objectives. They contend that setting clear objectives for using digital tools might help students become more adept at using technology in more complex ways over time. Hutchison and Woodward also emphasize how crucial it is to put learning objectives ahead of technological integration when planning lessons. They support deciding on educational objectives early in the planning phase before deciding on a technology. By addressing content-area goals in addition to introducing students to technological tools and new digital skills, this method guarantees that instructors accomplish true integration. This viewpoint is supported by Robyler (2003), who claims that the establishment of suitable goals and the creation of efficient strategies to reach them are essential

preconditions for success in every endeavour. Therefore, it seems sensible to assume that any technological project would follow a carefully thought-out strategy.

For a lesson to be effective and for instructional objectives to be met, the technological tools that are integrated into it must be carefully selected. The mere availability of technological tools does not ensure that they are appropriate for the topic, the learners' level, or how they will help achieve the learning objectives. Therefore, while selecting technology for instruction, it is important to take these elements into account. Bennett and Everhart (2003) share this point of view, contending that instructors may improve curriculum delivery and successfully modify classroom activities by using the right technology. But it is important to understand that using technology goes beyond just having hardware and an internet connection—how technology is integrated into the curriculum is what matters most.

Technological tools were chosen for the science lessons' integration throughout the lesson plan's organization based on their capacity to impact and improve higher-order thinking skills. The whole lesson was planned to include the students as important figures in the teaching process, according to the constructivist educational philosophy, and use a student-centered learning strategy. As a result, the lessons included simulations, especially 3D simulations enhanced by coding, to support the students' higher-order thinking abilities and help them complete tasks successfully. This strategy supports Polly's (2011) point of view, which emphasizes that the best use of technology occurs when students use higher-order thinking skills. Students may evaluate and synthesize inquiry results using technology-rich, learner-centered activities, which deepen their understanding and help them make connections across other disciplines. Such considerations heavily influenced the organization and selection of technological tools in the lesson plan.

Furthermore, virtual manipulatives have been shown to improve students' attitudes (Lee and Chen, 2010). More flexibility is provided by simulated activities compared to those involving real items, which helps teachers better convey topics. This adaptability supports the choice to include simulated exercises in the lesson plan. However, these decisions were ultimately guided by instructional objectives. Virtual manipulatives may be more effective than physical ones, according to Sarama and Clements (2009), especially for young children who are beginning to connect tangible and abstract concepts. They describe virtual manipulatives as having fewer distracting elements and

being more controllable, adaptable, expandable, and clean. Research demonstrating the benefits of virtual manipulatives for learning facilitation lends credence to this viewpoint.

The lesson's assessment phase is extremely important since it lets teachers assess the understanding of learners and determine if the objectives of the lesson have been accomplished. Utilizing technology during the assessment phase becomes essential given the lesson's integration of technology. In this implementation, interactive elements that enhance students' engagement and enjoyment have been integrated into the assessment process using technological tools like Wordwall, Kahoot, and ESL Games Plus. Irving (2015) highlights the importance of these technologies in the process of formative assessment, emphasizing their ability to enhance learning-oriented classroom settings and offer insightful information about students' progress across instructional sequences. Instantaneous feedback is one of the main benefits of employing technology for assessment. Beatty and Gerace (2009) point out that by providing quick feedback, technology can help overcome the issue of having little time to assess students' performance. In a similar vein, Preszler et al. (2007) stress the benefit of quickly gathering information on students' understanding by employing formative assessment provided by technology.

Furthermore, Ramsey and Duffy (2016) point out two main advantages of using technology in assessment: firstly, it facilitates individualized learning, enabling teachers to modify their lessons to fit each student's particular needs; and secondly, it frees up time in lecture-based courses for more interactive sessions, which encourage students to participate more deeply in the learning process. In a nutshell, integrating technology into the assessment phase has the potential to improve the learning process in general by offering quick feedback, assisting personalized learning, and encouraging students' participation in the classroom. It also makes it easier to evaluate students' learning effectively.

Including reflection in the organization of lesson plans integrated with technological tools is imperative for assessing their effectiveness in achieving instructional objectives. Additionally, it is critical to get feedback from teachers and students in order to assess the effectiveness of the integrated technological tools as well as the lesson as a whole. Thoughtful reflection allows teachers to assess how technology affects instruction and learning, and students' reflections offer insightful information about what they have learned. Data for reflection on the implementation were gathered

for the current study using a variety of methods, such as questionnaires, interviews, observations, and reflection journals kept by the researcher and the students. In order to determine teachers and students' usage patterns and skill levels, Bennett and Everhart (2003) stress the significance of evaluating the present state of technology use in classrooms. This may be accomplished by conducting surveys of teachers and students. Reflection also helps educators successfully negotiate the challenges of incorporating information and technology into the classroom. The ways in which reflection aids in the creation of instructional practices that combine content knowledge, pedagogical competence, and technical proficiency are highlighted by Jang and Chen (2010) and So et al. (2015). In the digital era, this integration is critical to improving teaching techniques and fostering successful professional growth. To put it simply, the inclusion of reflection and the gathering of instructors' and students' feedback are crucial elements in lesson planning that involve the integration of technology. Teachers may evaluate how technology affects teaching and learning, identify areas for development, and enhance their methods of education to better suit the requirements of their students by reflecting on their practice.

4.2.4. Discussions regarding the problems encountered in the process of integrating technology into science lessons and their solutions.

During the science lesson integrated with various technological tools, some minor challenges were encountered, prompting swift action to ensure the seamless integration of these tools into the instructional process. Challenges include time constraints, techno-centric distractions, excessive integration of technological tools, students' preference for specific computer hardware functionality, and selecting the appropriate tools for specific topics. To address these challenges, action plans were developed in collaboration with the validity committee members. Through proactive measures, all the challenges encountered were effectively remedied by the end of the implementation phase. This collaborative approach ensured that the instructional process remained effective and conducive to the students' learning despite the initial hurdles encountered.

A number of researchers have repeatedly noted that a major barrier to the integration of technology in education is time constraints (Al-Awidi & Aldhafeeri, 2017; Alfelaij, 2016; Mumtaz, 2000; Li & Walsh, 2010). The researcher in this current study ran into time restrictions during the first implementation. The lesson's intended technological

tools were effectively integrated; however, time constraints made it difficult to complete the evaluation of the lesson. More specifically, there was not enough time to perform a comprehensive assessment of the lesson through an interview, students' reflections, and questionnaires right after the lesson. To address this issue, a technology integration timeline was developed, outlining the technological tools to be integrated into the lesson, along with their designated time slots and durations. This strategy, which is supported by Dexter and Anderson (2002) as well as Lim and Khine (2006), places a strong emphasis on instructors working together to develop lesson plans and resources that use technology. By doing this, time restrictions that impede the successful integration of technology are reduced. In addition, adjustments were implemented during breaks between lessons to maximize efficiency. In order to optimize instructional time during the actual lesson period and speed the teaching process, these adjustments included pre-opening and logging into technological tools. The integration of technology into the teaching process was aided by proactively addressing time constraints and adopting strategic adjustments, resulting in the effective use of available resources and time.

Techno-centric distractions emerged as a notable challenge during the science lesson integrated with various technological tools. While there are many advantages to integrating technology into lessons, there are drawbacks as well. This finding is consistent with the claim made by Pérez-Juárez et al. (2023) that technology creates a paradox in students' lives by making it easier for them to participate in educational activities but also a source of distraction from completing tasks. In the current study, some students completed a simulated task ahead of time and then used their laptops to browse the internet for unrelated purposes. This conduct was similar to what McCoy (2016) found in a study that showed university students were utilizing digital devices for non-task activities for about 21% of the class period. The validity committee members in the current study recommended selecting somewhat challenging simulation activities to counteract this distraction and maintain students' interest throughout the session. After integrating a more challenging simulation task, the issue of techno-centric distraction was no longer observed. This change could be attributed either to the challenging nature of the simulation task or to the students paying closer attention to the lesson. In any case, the problem did not reoccur.

The excessive integration of technological tools into the instructional process posed a challenge during the science lesson. Six technological tools were utilized in the first

implementation: Wordwall, animation, two simulations, video, and Kahoot. The eighty-minute lessons proved to be overwhelming due to the number of tools, which also added to the time constraints encountered during the lesson. While all the integrated technological tools were freely available, their sheer quantity hindered optimal learning outcomes. Studies conducted in 2019 by Parker, Stylinski, Bonney, DeLisi, Wong, and Doty emphasize that when it comes to technology integration, quality matters more than quantity. Effective learning outcomes cannot be ensured by simply integrating technology into the lesson; instead, teachers must have the necessary knowledge and abilities to use technology in a way that promotes high-quality instruction. Although the integration of many technological tools has resulted in the students' expressing satisfaction and enhanced understanding, the overwhelming number may have impacted the efficacy and depth of learning experiences. Therefore, to guarantee that the students have meaningful and lasting learning experiences, a more deliberate and chosen approach to integrating technological tools is necessary.

The issue of excessive integration of technological tools was effectively addressed by adopting a more selective approach, prioritizing quality over quantity. Consideration was given to the number, quality, and relevance of technological tools, ensuring that only those contributing to the students' understanding, enjoyment, and engagement were integrated. This strategic approach is in line with Strom's (2021) suggestion, which highlights how crucial it is for educators to exercise caution when using technological tools and to keep students' engagement in mind. Teachers may maximize the efficacy of technology integration in the teaching process by giving priority to technologies that best support students' engagement and encourage learning. This concept was implemented in the third implementation, which only included three technological tools: an interactive video, a 3D simulation, and Kahoot. This simplified method worked well; neither the researcher nor the students reported any issues. The validity committee also suggested that the researcher develop his 3D simulation by himself, which would have precisely matched the learning objectives. This emphasizes the significance of matching technology use with particular learning goals and the critical role that instructional objectives play in directing the choice and integration of technological tools into lessons. This concept can help instructors make sure that integrating technology improves students' learning and makes it easier to accomplish learning goals.

Throughout the implementation, among the eight students who participated in the study, only three expressed concerns regarding the functionality of the computer hardware used during the lesson. The students utilized laptop computers, and following the lesson, they reported that the laptop's mouse or cursor moved too slowly, making it difficult for them to do work efficiently. Investigation revealed, however, that there was no hardware malfunction—rather, the students' preferred mouse/cursor speed was simply not being met. To address this issue, the mouse/cursor speed was adjusted to align with the students' preferences for subsequent lessons. This proactive approach ensured that the technological tools used in the instructional process were optimized for the students' comfort and usability, thereby enhancing the overall learning experience. Potential barriers to learning were reduced by quickly responding to the students' complaints and making the required adjustments, enabling a more seamless and successful integration of technology into the teaching process.

In conclusion, the key to successful integration of technology into science lessons lies in aligning the technological tools with the instructional objectives, ensuring their appropriateness for the students' levels, and seamlessly integrating them at the beginning, middle, and end of the lesson. Moreover, the tools should be interactive, fostering participation and collaboration among the students. This approach results in a smooth flow of the lesson, enhancing students' understanding of science concepts while making the learning experience enjoyable for them. By following these strategies, technology becomes an effective and engaging tool for enriching science education.

4.3. Recommendations

The recommendations outlined in this study are recommendations developed for further research. The recommendations for further research focused on guiding future inquiry and exploration in the field of technology integration in science education. Gaps in existing knowledge are highlighted, areas for deeper investigation are proposed, and methodologies or approaches are suggested for future studies. By addressing these recommendations, researchers can advance knowledge, deepen understanding, and generate valuable insights to inform future practice in technology integration in science education.

4.3.1. Recommendations for future practices

- **Align technological tools with learning objectives:** Future teachers should place great emphasis on aligning the technological tools they select and integrate into their lessons with the specific objectives of the lessons. This entails carefully evaluating each tool's ability to improve students' engagement and comprehension in relation to the curriculum requirements and learning objectives. It is essential to strike a balance between the range of tools at one's disposal and how well they work to achieve the intended learning objectives. Teachers may facilitate greater knowledge and mastery of subject matter by creating a dynamic and engaging learning environment that caters to varied learning preferences and complements the curriculum. Furthermore, making sure that technological tools are easily incorporated into the teaching process improves their usefulness and efficacy, which in turn helps students have more significant and lasting learning experiences.
- **Limit the number of technological tools:** It is advisable to prioritize the use of the most effective technological tools, regardless of their quantity. Integrating too many technological tools concurrently might overwhelm the students and impede their ability to study effectively. As a result, it is recommended to restrict the integration of technology to no more than three tools for each lesson. Strategically, one tool—such as interactive videos or animations—should be presented at the beginning of the lesson to lay the foundations. During the lesson, the second tool can be integrated to help with collaborative tasks such as 2D and 3D simulations. Lastly, interactive resources like Kahoot must be integrated for assessment at the end of the lesson. This approach helps to conduct a thoughtful and well-balanced use of technology in the classroom, encouraging participation, understanding, and efficient assessment methods.
- **Prepare the instructional setting in advance:** To optimize instructional time and minimize distractions during lessons, it is advisable to ensure that the instructional setting, whether a classroom or laboratory, is fully equipped with all the necessary technological tools prior to the commencement of the lesson. This proactive strategy will guarantee that valuable instructional time is not wasted on technological tool setup or technical troubleshooting, which may

otherwise result in time-related issues and distractions during instruction. Teachers may enhance their teaching effectiveness and provide a smooth learning experience for students by having the appropriate technological tools on hand and set up appropriately beforehand.

- **Tailor technological tools to students' levels:** Ensuring that the technological tools integrated and utilized during the lesson are appropriate for the students' understanding and skill level is crucial. To encourage participation and sustained attention, students should also be given moderately challenging technology-related tasks. Overly simple tasks might cause students to get disengaged and easily distracted since they can finish them fast and then sit idle and do other unrelated activities. By providing appropriately challenging tasks, teachers can encourage students to focus, invest effort, and remain actively engaged in the learning process. This strategy will lessen the influence of techno-centric distractions and create an atmosphere that is favourable for deep learning and skill development.
- **Promote active participation and interaction:** It is crucial to encourage students' engagement and active participation in technology-enhanced learning environments. It is recommended that teachers employ technological tools to accomplish this, including interactive videos and animations, quizzes, simulations, and collaborative activities. These elements will develop critical thinking and problem-solving skills, in addition to increasing students' engagement. While simulations will provide practical learning experiences that simulate real-world scenarios, interactive quizzes will offer immediate feedback and promote active participation. Engaging in collaborative activities may foster peer learning, teamwork, and communication. Teachers may build dynamic learning environments that enable students to take charge of their learning and develop the critical skills necessary for success in the digital age by integrating these elements into their instruction.
- **Continuously monitor and evaluate effectiveness:** It is essential to continuously monitor and evaluate the effectiveness of technological tools in enhancing students' learning outcomes. To achieve this, it is recommended that teachers collect feedback from both teachers and students to identify strengths, challenges, and areas for improvement. A variety of methods,

including surveys, questionnaires, interviews, and reflection journals, can be used to obtain feedback. Teachers can obtain important insights into how technological tools affect students' learning and instructional methods by methodically gathering feedback. With this knowledge, they will be able to select, integrate, and optimize technological tools more effectively, better serving their students' needs and enhancing learning outcomes. Furthermore, ongoing evaluation enables the modification and refining of teaching strategies over time, guaranteeing that technology is utilized to enhance students' learning.

- **Extend implementation period:** It is recommended that teachers extend the implementation period for a longer duration, such as one semester or a whole academic year, in order to fully examine the effectiveness of technology in enhancing students' learning. Teachers will be able to evaluate the long-term effects of technology integration on students' learning outcomes because of the more comprehensive and reliable data that will be collected over this extended period of time. Teachers may also gain more insight into the effectiveness of technological tools by monitoring changes in students' performance over time and identifying patterns, trends, and changes in the performance of their students. A longer period of implementation will also enable the identification of problems, adjustments, and refinements to teaching methods, guaranteeing continuous improvement and optimization of technology-enhanced teaching strategies.
- **Teachers should create and implement their own e-learning materials:** It is recommended that teachers explore developing and implementing their own technological materials in lessons. With the help of platforms like CoSpacesEdu, teachers may create unique 3D simulations and other interactive technological tools that are suited to their specific instructional needs. Teachers may address the specific needs and interests of their students, tailor learning experiences, and align resources with curricular objectives by developing their own technological tools. Creating and implementing unique technological tools will also give teachers the freedom to use their creativity, innovation, and problem-solving skills in the classroom. Through this

process, teachers can become active contributors to the evolution of educational technology and shape the future of teaching and learning.

- **Adjust technological tool settings to student preferences:** It is recommended that teachers ensure that the settings of technological tools are adjusted to meet students' preferences before integrating them into lessons. This includes adjusting mouse speed, font size, brightness, and other pertinent settings to improve students' comfort and ease of usage with the devices. Teachers may foster a more inclusive and accessible learning environment where students can effectively engage with technology by making accommodations for individual students' preferences and needs. Furthermore, modifying the settings to suit the preferences of the students encourages efficiency and productivity by freeing them up to concentrate more on learning objectives rather than overcoming technical difficulties. Personalized settings will improve the overall usability and efficacy of technological tools, which will help students have a positive and seamless learning experience.
- **Teachers should stay abreast of advancements in educational technology:** It is recommended that teachers keep up with the most recent advances in educational technology and actively seek out cutting-edge educational technology resources and platforms to enhance science education. Adopting cutting-edge technology like gamification, virtual laboratories, augmented reality, artificial intelligence, and 3D immersive virtual reality may greatly improve students' immersion and engagement in the learning process. With the help of these interactive and immersive technologies, students may be encouraged to be curious, creative, and critical thinkers. Teachers may build dynamic and fascinating learning environments that accommodate a variety of learning styles and preferences by implementing these cutting-edge tools into their teaching practices. Furthermore, it is recommended that teachers refrain from depending exclusively on antiquated and passive technological tools, including basic videos and two-dimensional simulations. Rather, they ought to make use of innovative and interactive technology to improve students' learning and promote a deeper understanding of scientific concepts.

By embracing innovation in educational technology, teachers can unlock new possibilities for enhancing teaching and learning in science education.

4.3.2. Recommendations for future scientific researches:

- **Employ various research designs:** Researchers can employ a range of research designs, such as experimental, quasi-experimental, and case study approaches, to explore effective methods for integrating technology into the teaching and learning process of science courses. By using different methodologies, researchers can obtain a comprehensive understanding of how technology impacts various aspects of science education, including student engagement, comprehension, and academic performance.
- **Examine different educational levels:** Researchers can investigate the most effective ways to integrate technology into science courses by examining different educational levels, such as high school and university. This approach will provide insights into how digital natives, who are accustomed to using technology in their daily lives, interact with and benefit from technological tools in an educational setting. Such studies can reveal differences in technology integration strategies and their effectiveness across various age groups and educational stages.
- **Comparative studies across science disciplines:** Comparative studies can be conducted to evaluate the impact of technology integration on students' academic performance and engagement across different science disciplines, such as biology, chemistry, physics, and earth science. By comparing the outcomes of technology use in different subject areas, researchers can identify discipline-specific benefits and challenges, leading to more targeted and effective integration strategies.

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Appendix 1. Technology Integration Timeline

3rd Technology Integration Timeline

Step	Activity	Time	Time
1	The arrangement of seating will be changed from rows to groups. The students' laptops will be set up. All the technological tools to be integrated into the lesson will be opened and logged into on the smartboard.	10 Minutes	10:10 – 10:20
2	The lesson overview, instructional objectives, and question-and-answer session will be presented and discussed with the students using the smartboard. This will serve to assess their relevant previous knowledge and warm them up for the upcoming lesson.	5 Minutes	10:20 – 10:25
3	An interactive video about the lesson will be displayed on the smartboard, followed by a discussion session.	10 Minutes	10:25 – 10:35
4	The lesson will be presented and discussed.	10 Minutes	10:35 – 10:45
5	Instruction on how to carry out the simulation task will be demonstrated to the students.	5 Minutes	10:45 – 10:50
7	B R E A K The technological tools to be used on the students' laptops (3D simulation) will be opened and prepared.	10 Minutes	10:50 – 11:00
8	The students will carry out 3D simulation task collaboratively on their laptops and answer questions on worksheet related to the task.	15 Minutes	11:00 – 11:15
8	A summary of the lesson will be provided, and the lesson will be summed up.	5 Minutes	11:15 – 11:20
9	Kahoot will be utilized for individual assessments, with students using their smartphones.	10 Minutes	11:20 – 11:30
10	The paper-pencil questionnaire will be completed individually.	5 Minutes	11:30 – 11:35
11	Exit tickets will be written by the students.	5 Minutes	11:35 – 11:40

Appendix 2. Permission from Anadolu University's Ethics Committee

Evrak Kayıt Tarihi: 17.10.2023

Protokol No: 633104

Tarih: 31.10.2023



ANADOLU ÜNİVERSİTESİ
SOSYAL VE BEŞERÎ BİLİMLER BİLİMSEL ARAŞTIRMA VE YAYIN ETİĞİ KURULU
KARAR BELGESİ

ÇALIŞMANIN TÜRÜ:	Yüksek Lisans Tez Çalışması
KONU:	Eğitim Bilimleri
BAŞLIK:	Fen Dersinde Öğretme-Öğrenme Sürecine Teknoloji Entegrasyonu: Bir Eylem Araştırması. (Technology Integration Into Science Course Teaching-Learning Process: An Action Research)
PROJE/TEZ YÜRÜTÜCÜSÜ:	Dr. Öğr. Üyesi İnci Zeynep ÖZONAY BÖCÜK
TEZ YAZARI:	Musah NUMAN
ALT KOMİSYON GÖRÜŞÜ:	-
KARAR:	Olumlu
Prof. Dr. Saime ÖNCE (Başkan-İkt. ve İdari Bil. Fak.)	
Prof. Dr. M. Erkan ÜYÜMEZ (Başkan Yardımcısı -İkt. ve İdari Bil. Fak.)	Prof. Dr. Fatime GÜNEŞ (Edebiyat Fak.)
Prof. Dr. Yıldız UZUNER (Eğitim Fak.)	Prof. Dr. Erkan YÜKSEL (İletişim Bil. Fak.)
Prof. Dr. Handan DEVECİ (Eğitim Fak.)	Prof. Dr. Kamil ÇEKEROL (Açıköğretim Fak.)

Appendix 3. Permission from The Ministry of National Education

Gelen Evrak Tarih ve Sayısı: 23.02.2024-702152



T.C.
ANKARA VALİLİĞİ
Milli Eğitim Müdürlüğü



Sayı : E-14588481-605.99-97245767
Konu : Araştırma İzni

21.02.2024

ANADOLU ÜNİVERSİTESİ REKTÖRLÜĞÜNE (Genel Sekreterlik)

İlgi : a) MEB Yenilik ve Eğitim Teknolojileri Genel Müdürlüğünün 2020/2 sayılı Genelgesi.
b) 05.02.2024 tarihli ve E-63784619-605-691423 sayılı yazınız.

Üniversiteniz Lisansüstü Eğitim Enstitüsü Eğitim Bilimleri Ana Bilim Dalı Eğitim Programları ve Öğretim yüksek lisans programı öğrencisi Musah NUMAN'ın Dr. Öğr. Üyesi İnci Zeynep ÖZONAY BÖCÜK danışmanlığında "Fen Dersinde Öğretme ve Öğrenme Sürecine Teknolojik Entegrasyonu: Bir Eylem Araştırması" başlıklı çalışması kapsamında İlimiz Çankaya ilçesine bağlı ortaokullarda uygulama talebi ilgi (a) Genelge çerçevesinde incelenmiştir.

Yapılan inceleme sonucunda, söz konusu araştırmanın Müdürlüğümüzde muhafaza edilen ölçme araçlarının; Türkiye Cumhuriyeti Anayasası, Milli Eğitim Temel Kanunu ile Türk Milli Eğitiminin genel amaçlarına uygun olarak, ilgili yasal düzenlemelerde belirtilen ilke, esas ve amaçlara aykırılık teşkil etmeyecek, eğitim-öğretim faaliyetlerini aksatmayacak şekilde okul ve kurum yöneticilerinin sorumluluğunda, gönüllülük esasına göre uygulanması Müdürlüğümüzce uygun görülmüş olup çalışma tamamlandıktan sonra çalışmanın bir nüshasının 30 iş günü içerisinde arge06_arastirma@meb.gov.tr adresine PDF olarak gönderilmesi gerekmektedir.

Bilgilerinizi ve gereğini rica ederim.

Yaşar KOÇAK
Vali a.
Milli Eğitim Müdürü

Ek : Uygulama Araçları (2 Sayfa)

Dağıtım:
Gereği:
Anadolu Üniversitesi

Bilgi :
Çankaya İlçe MEM

Adres :

Telefon No :

E-Posta:

Kep Adresi : meb@hs01.kep.tr

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Bilgi için: Elvan ÖZBEK

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İnternet Adresi: Faks:

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Appendix 4. Validity Committee Meeting Record

2nd Validity Committee Meeting (8:00 – 9:30 PM)

Thursday, 23rd November, 2023.

The following were discussed during the meeting:

1. I can use transcription software to transcribe the interviews I conducted with the students. That would make the process easier. Azure transcription software was recommended.
2. After completing the data collection, I need to compose a brief and concise data analysis for presentation at the upcoming validity committee meeting. The focus should be on highlighting encountered problems and their resolutions. It is unnecessary to present all the raw data; this approach allows us more time during the meeting to discuss and find solutions to the encountered issues, as well as to discuss the subsequent lesson plan. Additionally, I must ensure to send the analysis by Wednesday at the latest, allowing committee members ample time for review before our meeting the next day.
3. In the previous implementation, there was an issue of techno-centric disruptions, wherein students completed their simulation task and became overly engrossed in unrelated activities on their laptops. Cigdem Hoca inferred that the simulation task might have been too easy for the students, leading them to complete it quickly and subsequently lose focus on the lesson content and the teacher. Cigdem Hoca suggested that in the subsequent lesson, I should make the simulation task slightly more challenging for the students to ensure they spend an adequate amount of time on the task.
4. Furthermore, during the meeting, it was discovered that some students provided conflicting responses in the questionnaire. For instance, a student rated the difficulty of the problem encountered in the lesson as 4 on a scale of 1-10, where 1 denotes being very easy and 10 being very difficult. However, the student also stated that they did not encounter any challenges in the lesson. It was suggested that I review the questionnaire before conducting interviews, allowing me to probe and gather more detailed responses from students in such cases.
5. It was also suggested that I conduct assessments individually rather than in a group, particularly in tools like Kahoot and other assessment tools.

6. It was also suggested that, to avoid encountering any time constraints during the lesson that might hinder or prevent the integration of technological tools, I should create a technology integration timeline outlining the activities to be carried out and their scheduled times. This plan is intended to ensure effective time management.



Appendix 5. Researcher's Pre-Implementation Reflection Journal

Pre-implementation Reflection Journal

Date: 19th November, 2023 / Sunday

Place: Home

Time: 8:00 pm

Dear diary,

Tomorrow, I'll be presenting a science lesson to my 7th-grade students, incorporating a variety of technological tools. This marks the implementation phase of my action research, which is focused on discovering effective methods to integrate technology into the teaching and learning process of the science course. My aim is to improve my instructional approach, identify technological tools that can enhance students' understanding of key science concepts, and address any challenges that may arise during the integration of technological tools into the science lesson.

I plan to enhance the science lesson by integrating various technological tools, including video, animation, simulation, Cambridge Lower Secondary Science Stage 8 software, and online games. The chosen topic for this implementation is forces and motion, a subject laden with abstract concepts such as gravity, contact force, and friction.

The chosen topic for this implementation is forces and motion, a subject laden with abstract concepts such as gravity, contact force, and friction. To facilitate a better understanding of these complex ideas, I aim to present the technological tools in a clear and easily digestible manner. Utilizing videos and animations, I will cover balanced and unbalanced forces as well as Newton's Third Law of Motion. These visual aids will serve as audio-visual learning resources, making it easier for students to grasp the concepts involved. The animation will also guide students through a step-by-step simulation activity, providing practical insights into proving Newton's Third Law of Motion. I have selected simulations from OLABS and PhET, which will allow the students to perform activities based on the animations they will watch.

To assess their understanding of the lesson, I will integrate engaging games such as Wordwall and Kahoot. While the former is open-access, it is worth noting that I have subscribed to Kahoot's free account and personally curated the assessment questions. Additionally, all these technological tools were evaluated during our first validity committee meeting, where members deemed them appropriate for the students' level.

Furthermore, it is important to highlight that, except for Kahoot, all the other technological tools are freely available on the internet, aligning with the accessibility and openness of the educational resources chosen for this lesson.

Additionally, prior to implementing the lesson, I will have all the technological tools opened and minimized on the smartboard. I will repeat this on the laptops assigned to the students for the lesson. Following this, I will organize the seating arrangement by transitioning them from rows to two groups, each comprising four desks, given that there are eight students in the class.

Following the technological tools setup, I will commence the lesson with the assistance of the Cambridge Lower Secondary Science Stage 8 software. I will use this platform to introduce the lesson, outline the objectives, and highlight the technological tools that will be integrated into the lesson. Subsequently, I will engage the students by displaying a video, serving both as an introduction to the lesson and a catalyst for a discussion to address the introductory questions.

As the lesson progresses, I will strategically incorporate video and animation when needed, enhancing the explanation of abstract concepts. When it is time for the simulation task, the animation will guide the students by displaying instructions before they collaboratively undertake the task. During this phase, some students will be tasked with reading the instructions, while others will execute them. I will be present to offer support and guidance, by providing scaffolding where necessary to ensure a comprehensive understanding of the technological tools and the tasks.

Following the simulation task, I will wrap up the lesson by summarizing the lesson and addressing any lingering questions or concerns the students may have. Subsequently, we will transition to the assessment phase of the lesson, utilizing Wordwall and Kahoot. For the Wordwall assessment, students will collaboratively respond to questions as a group. They will take turns answering questions, with Group 1 tackling the first question and Group 2 handling the second, in that order. Moving to Kahoot, the assessment will continue collaboratively, but with a slight modification. Instead of using their phones, the students will use their laptops to collaboratively answer the questions. This collaborative approach aims to encourage teamwork and shared understanding as they navigate the assessment challenges together.

In the post-implementation phase, I will initiate data collection from the students through various methods. Initially, I will distribute a three-question questionnaire aimed at eliciting their ratings and opinions on the challenges faced during the lesson, the impact of technological tools on their understanding, and their overall enjoyment of the science lesson. Following this, each student will be provided with a sticker to articulate their personal experiences with the integration of technological tools into the lesson. To delve deeper into their perspectives, a focus group interview will be conducted, comprising four students from each group. The interview will centre around their experiences with the technological tools, any encountered challenges or problems, how these challenges or problems were resolved, and the extent to which the tools enhanced their understanding and performance in the lesson.

Simultaneously, I will diligently document my observations in a detailed field note. This information will be used to complete the observation protocol and contribute to the post-implementation reflection journal. The analysis of data from these diverse sources will provide a comprehensive understanding of the impact of technology integration on the students' learning experiences, allowing for valuable insights and future improvements.

Dear diary, to be honest, I find myself in a state of nervous anticipation about what lies ahead tomorrow. The plans I have meticulously crafted for implementation are teetering on the edge of uncertainty. My mind is clouded with worries—what if time slips away before I can seamlessly integrate all the technological tools into the lesson? What if the students become overwhelmed by the array of tools I have prepared? And then there's the looming fear of the unpredictable, like the Wi-Fi acting up or an unexpected blackout disrupting our plans. These questions relentlessly echo in my mind, creating a sense of unease. At this juncture, I can only hope and pray that everything unfolds according to plan. The anxiety is palpable, but I choose to embrace optimism. See you after implementation.

Bye diary.



Appendix 6. Post-Implementation Reflection Journal

Post-implementation Reflection Journal 1

Date: 20th November, 2023 / Monday

Place: School

Time: 12:00 pm

Dear diary,

I am delighted to share that I have successfully executed my first science lesson, fully integrated with technology. Despite encountering challenges during the implementation, I consider it a success. The primary goal of this implementation was to enhance my teaching practice by integrating technological tools into my science lesson. I aimed to explore effective ways of integrating these tools and understand how they could enhance students' understanding of key scientific concepts. Based on my observations, as well as the performance and feedback received from students through the assessment tools, questionnaires, and interviews, I can confidently say that my objectives for the implementation have been achieved.

During the lesson, I successfully integrated all the planned technological tools, including a video, an animation, two simulations, Wordwall, and Kahoot. From my observations, the video provided a concise and effective explanation of the lesson, contributing to a better understanding for the students. Additionally, the animation proved to be a valuable resource, offering a straightforward yet insightful step-by-step guide for carrying out the simulation task. The students actively and cooperatively engaged in the simulation tasks, leading to a successful implementation. Observing their responses, it was evident that the students not only understood the tasks well but also really enjoyed them. Their enthusiasm and full engagement during the tasks reflected a positive learning experience.

During the assessment stage of the lesson, the students participated in Wordwall and Kahoot. Based on my observations, the students demonstrated excellent performance, as reflected in their scores, indicating a thorough understanding of the lesson. Both groups achieved perfect scores of 5/5 in the Wordwall and impressive scores of 9/10 in the Kahoot. Notably, the first group secured the top position on the Kahoot scoreboard, answering questions more swiftly than the second group. From my observations, the students really enjoyed the interactive games and expressed a desire for more. Unfortunately, due to time constraints, we couldn't extend the game session further. The

positive engagement and request for more games underscored the success of the assessment activities in reinforcing their understanding of the lesson.

After the lesson, I gathered valuable insights from the students regarding their opinions and experiences with the integration of technological tools into the science lesson. I employed a questionnaire consisting of three questions, focusing on the problems they encountered, how the technological tools contributed to their understanding, and their overall enjoyment of the lesson. The least feedback received on a scale of 1–10, where 1 signified "very easy" and 10 denoted "very difficult," for the problems encountered during the lesson was 4. Additionally, on a scale of 1–10, where 1 represented "not effective at all" and 10 indicated "extremely effective," the least feedback given on technology's contribution to understanding the lesson was 5. Furthermore, on a scale of 1–10, where 1 meant "not enjoyable at all" and 10 meant "extremely enjoyable," the least feedback received for the enjoyment of the lesson with technology was 6. In addition to numerical responses, the students provided written reflections in the questionnaire and reflection journals in the form of an exit ticket, offering insightful accounts of how the integrated technological tools enhanced their understanding of the lesson.

Moreover, the students were interviewed to delve deeper into their experiences, focusing on which technological tools were used, how they were utilized, the impact of these tools on their understanding, emotional responses to the technology, encountered problems, the influence on their performance, and their general views on the integration of technological tools into the science lesson. This comprehensively collected feedback provided a more nuanced understanding of the students' perspectives and experiences with the science lesson integrated with various technological tools. Generally, the students gave positive expressions, expressing that the tools really enhanced their understanding of the lesson and fostered cooperative learning. The lesson was enjoyable, and they did not face any problems. However, only one student expressed facing a problem with the speed of the mouse he was using after the lesson. Other than that, everything went as anticipated.

I did encounter some challenges during the implementation. Addressing them in the classroom, I successfully managed a few while devising plans to tackle the rest before my subsequent lesson. Lack of time was a prominent challenge. Despite my initial plan to seamlessly integrate technological tools and collect feedback from students, the constraints of time prevented me from executing this part of the plan effectively. Techno-

centric distractions emerged as another obstacle. The students became so engrossed in the technological tools that their focus shifted away from the teacher and the core lesson content. In response, I intervened by minimizing distractions and redirecting their attention back to the lesson. Excessive technology integration was also noted as a challenge. The array of technological tools integrated into the lesson seemed to be overwhelming within the given time frame. This realization prompted me to reflect on a more streamlined approach for subsequent lessons. These challenges, while present, served as valuable learning experiences. They have informed my plans for future lessons, ensuring a more refined and effective integration of technological tools. Until later.

Bye diary, 😊



Appendix 7. Student Exit Ticket Sample

Reflection

In Today's lesson we learned about Describing Movement using: an Interactive video, 3D simulation and Kahoot. I think the use of technology helps me a lot with visualizing. It also makes the lesson more fun because we can interact. Just like how we did with the video, simulation and Kahoot. We watched the video paused it and answered some questions, for the simulation it was interesting because it was 3D. We coded and then we put our results on a graph and answered questions. And in Kahoot we solved questions and we had to be fast which I think made it fun. Overall using technology in Science lessons makes it fun and they help you understand better. This learning method also improved my performance.

Appendix 8. Researcher Observation Protocol Sample

OBSERVATION PROTOCOL	
Setting: International Gokkusagi Schools Individual Observed: 7 th grade students Observation #: (first observation) Observer Involvement: Participant as observer Date/Time: 20 th November, 2023 / Monday Place: Classroom Duration of Observation: 10:10 – 11:40am	
Descriptive Notes	Reflective Notes
(Detailed, chronological notes about what the observer sees, hears; what occurred; the physical setting)	(Concurrent notes about the observer's thoughts, personal reactions, experiences)
1. Which technological tools were used at which stages of the course and how?	1. Various technological tools were integrated in the lesson, including a video, an animation, two simulations, Wordwall, and Kahoot. The video was presented at the outset, while in the middle of the lesson, both the animation and simulations were seamlessly integrated. Finally, during the assessment stage at the end of the lesson, Wordwall and Kahoot were integrated.
2. Which activities and how were they carried out using technological tools from the beginning to the end of the course?	2. At the outset of the lesson, I utilized a video displayed on the smartboard to deliver a concise and vivid explanation of the topic at hand. This visual aid served as an effective introduction, setting the stage for the learning objectives. Midway through the lesson, an animation sourced from OLABS took center stage. It provided a step-by-step guide and visually demonstrated the procedure for conducting an experiment to illustrate Newton's Third Law of Motion. The lesson progressed with the students actively engaging in a simulation from OLABS. This simulation allowed them to practically carry out an experiment to prove Newton's Third Law of Motion, fostering a hands-on learning experience. Additionally, another simulation from PhET was integrated, offering the students an opportunity to explore the dynamics of balanced and unbalanced forces acting on an object. For the assessment stage, Wordwall and Kahoot were employed. The students, working collaboratively in groups, played these interactive games on their laptops. This marked the conclusion of the lesson, providing a dynamic and engaging platform for assessing their understanding of the lesson.
3. How was the students' interaction with the technological tools? What were the students' reactions at each stage?	3. Overall, the students were highly engaged in the tasks they completed on their laptops. They solely focused on observing the video and animation without engaging in any activities on either their laptops or the smartboard. Following the display of the video at the beginning and the animation in the middle of the lesson, the students were seen nodding their heads in agreement, signaling a clear understanding of the content. Notably, their smiling faces further indicated understanding and enthusiasm for the lesson. Moreover, based on my observations, the students exhibited a positive and collaborative attitude as they worked on simulation tasks, Wordwall, and Kahoot on their laptops during the middle and at the end of the lesson. Their enjoyment was particularly evident during the Kahoot activity, where they not only participated actively but also expressed a desire to play more.

4. How was the students' participation in the lesson?	4. In general, the students actively engaged in the lesson by attentively watching the video, animation, and the rest of the content delivered via the smartboard. During the collaborative simulation task, they worked together in groups, with one student reading the instructions while others executed them on their laptops. Even when not directly involved in a task, the students' maintained focus on both their laptops and the smartboard. However, there were instances where some students, after completing their assigned tasks, became fully engrossed in unrelated activities on their laptops. Unfortunately, during these times, their attention was diverted from the teacher and the ongoing lesson.
5. What were the problems / difficulties students encountered regarding the use of technological tools in the course?	5. Throughout the lesson, no student was observed facing any issues or challenges. However, after the class, a student raised a concern about controlling the laptop's mouse. Specifically, he mentioned that the mouse seemed slower than he preferred, but he was able to manage with it. He inquired whether there could be adjustments made to address this issue for our future lessons.
6. How were the problems / difficulties encountered by students regarding the use of technological tools in the course resolved?	6. The issue regarding the laptop mouse not functioning optimally was investigated. Upon investigation, it was determined that the problem stemmed from a setting related to the cursor speed. Subsequently, the speed of the cursor was adjusted to ensure it moved slightly faster than before, resolving the problem.
7. How did the use of technological tools affected the classroom environment/order?	7. In response to the integration of technological tools into the lesson, the seating arrangement of the students was changed from rows to groups. This facilitated collaborative learning, allowing students to engage in lessons and complete tasks using technological tools collectively. This change not only promoted a more interactive classroom environment but also streamlined classroom management. With attention and tasks focused on group activities rather than individual tasks, it became more efficient to oversee and guide the students. Furthermore, the collaborative nature of the classroom, enhanced by the use of integrated technological tools, enabled students to provide peer support. This was evident during simulation tasks and assessments on platforms like Wordwall and Kahoot, where students actively engaged in peer scaffolding, assisting each other in problem-solving and task completion.

Appendix 9. Observation Field Note

Observation Field Notes

Date: 20th November, 2023 / Monday

Place: 7th Grade Classroom

Time: 10:10 – 11:40am

Upon entering the classroom, I brought along two laptops and the Cambridge Lower Secondary Science Stage 8 textbook, with the intention of integrating technological tools into my science lesson. My initial step involved rearranging the students' seating arrangement from rows to two groups. In total, there were eight students in the classroom, with one student absent on that day. The first group was composed of three female students and one male student, while the second group included two male students and one female student. By 10:22am, the students were comfortably seated, each group equipped with a laptop in front of them. This setup aimed to enhance the science lesson through interactive and collaborative learning facilitated by the use of technology.

Following the seating arrangement adjustments, I proceeded to open the Cambridge Lower Secondary Science Stage 8 software on the smartboard. With the software displayed, I took a moment to introduce the topic and outline the objectives of our lesson. I made it clear to the students that our approach today would involve the seamless integration of technological tools into the science lesson. The primary goal was to explore the effective integration of technology, emphasizing how it could elevate the students' understanding and enjoyment of the lesson. I then provided an overview of the specific technological tools we would be incorporating, which included a video, an animation, two simulations from OLABS and PhET, as well as Wordwall and Kahoot. This variety of technological tools aimed to add a dynamic and interactive dimension to our science lesson, fostering a more engaging and enriching learning experience for the students.

Following the lesson introduction, I conducted a brief question and answer session to assess the students' relevant previous knowledge. Subsequently, we proceeded to watch a short video from OLABS, elucidating the topic of forces and motion, with a particular emphasis on Newton's Third Law of Motion. After watching the video, we returned to the Cambridge Lower Secondary Science Stage 8 software displayed on the smartboard and continued with the lesson.

Next, we delved into the section of the lesson that involved a hands-on activity for students to demonstrate Newton's Third Law of Motion. I clarified to the students that this particular activity would be conducted using a simulation. As this part of the lesson unfolded, we found ourselves with approximately five minutes remaining before the scheduled break. Utilizing this time effectively, I introduced an animation from OLABS, outlining the materials essential for the upcoming activity and providing a step-by-step guide on how to execute it. By 10:50 am, the designated break time had arrived, prompting the students to leave the classroom.

During the ten-minute break, I took the opportunity to set up the simulations, Wordwall, and Kahoot on both the students' laptops and the smartboard. To ensure their full engagement, I minimized all windows on the students' laptops, directing their attention toward the activities displayed on the smartboard. By 11:00 am, as the students returned from the break, they took their seats within their respective groups, fully prepared to embark on the simulation task.

I proceeded to maximize the simulation windows on the students' laptops, allowing them to collaboratively engage in the simulation task. One student assumed the role of reading the task instructions, while the other group member(s) actively executed the task. This specific simulation, sourced from OLAB, centered around demonstrating Newton's Third Law of Motion. As the students carry out the activity, I could see they were really into it. They were talking and smiling a lot, showing they were genuinely enjoying it. After we finished that part, we moved on to another simulation from PhET. This one was about balanced and unbalanced forces, digging into the effects of forces on an object. The students kept up their enthusiasm, exploring different scenarios and having a good time with it.

Following the simulation tasks, we returned to the lesson displayed on the smartboard. We dove into the topic of calculating the net force acting on an object. I broke down the concepts and walked the students through numerous examples on the whiteboard using a marker. After this hands-on session, we wrapped up the lesson with a brief closure. During this time, the students mainly asked questions, focusing particularly on the calculations of the net force. I addressed all their queries. By this point in the lesson, it was around 11:20 am, and we had roughly 20 minutes left to finish with the remaining assessment activities.

The technological tools used lastly, thus at the assessment stage were Wordwall and Kahoot. Initially, the task was projected onto the smartboard, and the students collaboratively responded to the questions as a group. The Wordwall game featured ten questions, focusing specifically on the calculation of net force acting on objects. Subsequently, we engaged in a Kahoot session, comprising ten questions covering the entire lesson. The students participated in the Kahoot on their laptops, collaborating within their groups. Notably, the students really enjoyed these online games, showcasing enthusiastic collaboration as they worked together to formulate answers. Their responses provided me with assurance that the lesson had been well understood. In the Wordwall game, both groups achieved a perfect score of 5/5. In the Kahoot session, both groups scored 9/10, with the first group securing the top spot on the scoreboard. Their quicker responses earned them extra points. Although the students expressed a desire to continue playing Kahoot, time constraints prevented further games. This activity marked the end of the lesson.

After the completion of the assessment activities, I informed the students that they would be required to fill out a brief questionnaire reflecting on their experience with the technology-integrated science lesson. At this point, it was around 11:31 am, leaving us with approximately nine minutes before the students would head out for their lunch break. The questionnaire delved into their encounters with any challenges during the technology-integrated lesson, how the technological tools contributed to their understanding, and their overall enjoyment of the lesson due to the integrated technology. The questionnaire included a rating scale from 1-10 for them to express their experiences. Once I explained the questionnaire and its components, I rearranged their seating from groups into rows. The students then individually completed the questionnaire. Additionally, I asked them to write an exit ticket—a brief reflection on the lesson. Although the lesson had officially ended, I encouraged them to jot down their thoughts immediately upon returning from lunch. True to their commitment, the students did so promptly.

Throughout the implementation, three significant challenges emerged: lack of time, techno-centric distractions, and an excessive integration of technological tools. Firstly, the issue of time posed a notable challenge. It took nearly twenty minutes to arrange the seating, set up the students' laptops, and open and log into the various technological tools, including the Cambridge Lower Secondary Science Stage 8 software. To address this

concern, I adapted by utilizing the break time to open and log into the technological tools, recognizing that doing so during the regular lesson period would be time-consuming. Time constraints resulting from the integration of numerous tools meant that the original lesson plan could not be fully executed. Additionally, due to the lack of time, the students were unable to complete the exit ticket in the classroom. Completing this reflection task within the classroom setting would have allowed them to share their experiences while the lesson was still fresh in their minds.

The issue of techno-centric disruptions surfaced as students became overly engrossed in the technological tools, particularly the simulations, diverting their attention away from the teacher and the core lesson content. Even after the designated task, some students continued to engage in unrelated activities on their laptops, detracting from the ongoing lesson. To address this challenge, I implemented a solution by minimizing all open windows and putting the laptops to sleep during periods when the students were supposed to focus solely on the teacher and participate in the lesson. This approach effectively redirected their attention back to the lesson, fostering increased participation and attentiveness. Laptops were only opened and utilized during specific sections of the lesson, such as when carrying out simulation tasks or playing Kahoot. This strategy aimed to strike a balance between leveraging technology for enhanced learning experiences and maintaining a focused and engaged classroom environment.

The issue of excessive technology integration emerged as a challenge during the lesson, marked by the integration of multiple technological tools within a short timeframe. The lesson integrated a video, an animation, simulations from OLABS and PhET, as well as Wordwall and Kahoot. The transition from one technological tool to another consumed valuable lesson time. Unfortunately, this problem was recognized post-lesson, preventing immediate remediation in the classroom setting. However, a plan has been devised to address this concern in subsequent lessons. The approach involves more deliberate selection of technological tools, ensuring their clear alignment with instructional objectives. The goal is to integrate the most relevant tools, incorporating at least one video, animation, simulation, and an online game. Additionally, for assessment purposes, the plan is to consolidate the games into a single platform, preferably Kahoot, given its popularity among the students. This strategic move aims to strike a balance, ensuring the effective use of technological tools without overwhelming the students and allowing for better time management to cover other essential aspects of the curriculum or lesson.

Appendix 10. Semi-Structured Interview Form

Semi-Structured Interview Form for Students

Interview No:

Interview Date:.....

Interview Time:.....

Interview Place / Setting:.....

Participants:.....

Questions

1. What did you learn in class today?
2. Were technological tools used in the lesson?
 - a. (If the answer is yes) Which technological tools and equipment were used and how?
 - b. When were these technological tools and equipment used in the lesson (at the beginning, middle, end of the lesson)?
3. What impact did the technological tools used in the course have on your understanding of the course? (How did it affect the understanding of the lesson?)
4. How did the use of technological tools and equipment in class make you feel? Can you explain a little bit why it feels that way?
5. Have you encountered any problems while using technological tools and equipment in the course?
 - a. (If yes) What were these problems/challenges?
 - b. How were these problems you encountered in the course solved?
6. Has there been any change in your grades or performance since you started using technological tools and equipment in your classes?
 - a. (If the answer is yes) Could you please explain what kind of change occurred?
7. What do you think about the use of technological tools in science lessons?

Appendix 11. Questionnaire and Student Sample

Questionnaire on Science Lesson Integrated with Technology for 7th Grade Students

Problems Encountered

1. a. On a scale of 1-10, how would you rate the level of difficulty/problems you encountered during the lesson?

(1 being very easy, 10 being very difficult). Tick ✓ a number.

1	2	3	4	5	6	7	8	9	10

- b. Describe any problems you encountered while having a science lesson integrated with technology.

.....

.....

.....

.....

Technology's Contribution to Understanding

2. a. On a scale of 1-10, how effective do you think technology was in helping you grasp the concepts taught?

(1 being not effective at all, 10 being extremely effective) Tick ✓ a number.

1	2	3	4	5	6	7	8	9	10

- b. How has the integration of technology influenced and contributed to your understanding of the science lesson?

.....

.....

.....

.....

Enjoyment of the Lesson with Technology

3. a. On a scale of 1-10, how would you rate your overall enjoyment of the lesson?

(1 being not enjoyable at all, 10 being extremely enjoyable) Tick ✓ a number.

1	2	3	4	5	6	7	8	9	10

- b. In your opinion, how does the integration of technology in science lessons enhance the overall enjoyment of the learning experience?

.....

.....

.....

Appendix 11. Questionnaire and Student Sample

Questionnaire on Science Lesson Integrated with Technology for 7th Grade Students

Problems Encountered

1. a. On a scale of 1-10, how would you rate the level of difficulty/problems you encountered during the lesson?
(1 being very easy, 10 being very difficult). Tick ✓ a number.

1	2	3	4	5	6	7	8	9	10
✓									

- b. Describe any problems you encountered while having a science lesson integrated with technology.

I didn't encounter any problems. It was fun and easy to understand.

Technology's Contribution to Understanding

2. a. On a scale of 1-10, how effective do you think technology was in helping you grasp the concepts taught?

(1 being not effective at all, 10 being extremely effective) Tick ✓ a number.

1	2	3	4	5	6	7	8	9	10
									✓

- b. How has the integration of technology influenced and contributed to your understanding of the science lesson?

I could understand very fast and especially the simulation we did today was very interesting. It was 3D and we did coding as well.

Enjoyment of the Lesson with Technology

3. a. On a scale of 1-10, how would you rate your overall enjoyment of the lesson?

(1 being not enjoyable at all, 10 being extremely enjoyable) Tick ✓ a number.

1	2	3	4	5	6	7	8	9	10
									✓

- b. In your opinion, how does the integration of technology in science lessons enhance the overall enjoyment of the learning experience?

It helped me understand better and we also did the simulation with my classmates which made it more fun. But the kahoot was my favorite. It was fun and it made me understand the best.

Appendix 12. Lesson Plans

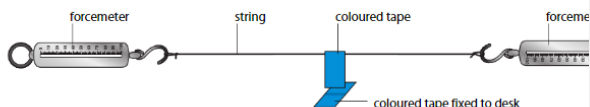
LESSON PLAN 1

PART 1

Course Title	Science
Class	7th Grade
Unit	Unit 3: Forces and energy
Topic	3.1 Forces and motion
Time	80 minutes
Date	20 th November 2023
Coursebook	Cambridge Lower Secondary Science Learner's Book 8

PART 2

Learning Objectives	By the end of the lesson the students will: 1. Understand what is meant by balanced and unbalanced forces. 2. Describe the effects of balanced forces on motion. 3. Describe the effects of unbalanced forces on motion.
Prior Knowledge Required for Students	Students have a basic understanding of forces and motion concepts, including an awareness of forces, types of motion, and how they influence objects.
Unit Concepts and Symbols:	Balanced, change direction, direction, force, opposite, slow down, and unbalanced.
Teaching-Learning Strategies, Methods and Techniques	Question and answer, presentation, demonstration, discussion, experimentation, cooperative learning.
Technology Integration Tools	Simulation: https://phet.colorado.edu/sims/html/forces-and-motion-basics/latest/forces-and-motion-basics_all.html https://amrita.olabs.edu.in/?sub=1&brch=1&sim=105&cnt=4 Animation: https://amrita.olabs.edu.in/?sub=1&brch=1&sim=105&cnt=214 Video: https://amrita.olabs.edu.in/?sub=1&brch=1&sim=105&cnt=384
Teaching and Learning Context	Getting started The students will work in groups to discuss answers to these questions. What is the unit of force? How are forces shown on diagrams? One or more forces always act on any object on Earth. Is this true? Main teaching ideas 1. Balanced or unbalanced? A discussion will be held with the purpose of helping students understand that objects that are stationary or moving at a constant speed have balanced forces acting on them, while objects that are not changing speed or direction have unbalanced forces acting. Additionally, we

	will explore the forces involved when an object starts to move, slows down, or changes direction. 2. Measuring balanced and unbalanced forces. Students will receive guidance in conducting an experiment to explore the impacts of balanced and unbalanced forces on an object. Initially, they will undertake this activity using a simulation, followed by hands-on experimentation in the laboratory setting. Set up the equipment as shown in the diagram. 
Resources	Workbook: 3.1A, Balanced forces 3.1B, Unbalanced forces 3.1C, Changing direction Worksheet: Worksheets 3.1, Effect of balanced and unbalanced forces.
Field Trips / Co-Op / Outings / Lab	Classroom

PART 3

Assessment	Students will answer the questions on the worksheet. Wordwall https://wordwall.net/resource/25453392/science/balanced-and-unbalanced-forces Kahoot https://play.kahoot.it/v2/lobby?quizId=3d52b43a-c3e4-4810-98dc-fe7836d5a41b

PART 4

Explanations Regarding the Implementation of the Plan	The topic will be studied within the suggested 80-minute lesson period, and the evaluation activities will be carried out to achieve the stated learning objectives.

PART 5

Reflection	

Numan Musah
Science Teacher

Successful 20/11/2023
Name Surname
School Principal

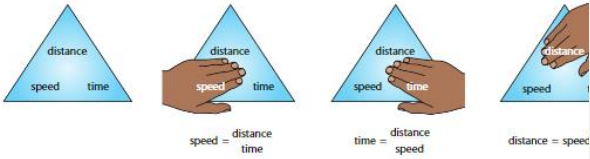
LESSON PLAN 2

PART 1

Course Title	Science
Class	7th Grade
Unit	Unit 3: Forces and energy
Topic	3.2 Speed
Time	80 minutes
Date	27 th November – 1 st December 2023
Coursebook	Cambridge Lower Secondary Science Learner's Book 8

PART 2

Learning Objectives	By the end of the lesson the students will: 1. Understand what is meant by speed. 2. Learn about the unit of speed. 3. Be able to calculate speed
Prior Knowledge Required for Students	Students have basic concepts related to measurement, units, and mathematics, as well as a fundamental understanding of the concept of distance.
Unit Concepts and Symbols:	Average speed, calculate, constant, m/s, metre, metres per second, per, second, and speed.
Teaching-Learning Strategies, Methods and Techniques	Question and answer, presentation, demonstration, discussion, experimentation, cooperative learning.
Technology Integration Tools	Simulation: https://phet.colorado.edu/sims/cheerpj/moving-man/latest/moving-man.html?simulation=moving-man Game: https://www.eslgamesplus.com/speed-distance-and-time-physical-science-game/ Animation: https://www.youtube.com/watch?v=e28-lcdAMHg Video: https://www.youtube.com/watch?v=EGqpLug-sDk
Teaching And Learning Context	Getting started The students will work in groups to discuss answers to these questions. What are the speed limits of cars where you live? Signs showing speed limits usually do not have units. What are the units used for speeds of cars? Main teaching ideas 1. Units of speed A discussion will be held with the purpose of helping students relate three quantities: speed, distance and time. Students will be made to understand that, speed is a measure of how quickly an object moves from one place to another and it has different units. For example, the speed of ships is often measured in knots, whereas aeroplane often use Mach. Some countries use road speed limits in kilometres per second, whereas others use miles per hour. However, the standard unit of for speed is metres per second, written as m/s. 2. Calculating speed

	The way speed is calculated is linked to the unit metres per second, m/s. Number of metres travelled in each second = total distance travelled / total time. Number of metres travelled in each second = speed. Speed = total distance travelled / total time. This can be summarized as, Speed = distance / time. The equation for speed can be used in a formula triangle. This means it can also be used to calculate: Distance travelled if the speed and time are known. Time taken if the speed and the distance travelled are known. 
Resources	Workbook: 3.2A, Units of speed 3.2B, Calculating speed 3.2C, Calculating distance and time Worksheet: 3.2A, Calculating speed, distance and time. 3.2B, Calculating speed, distance and time. 3.2C, Calculating speed, distance and time.
Field Trips / Co-Op / Outings / Lab	Classroom

PART 3

Assessment	Students will answer the questions on the worksheet. Kahoot https://play.kahoot.it/v2/lobby?quizId=182b0ed1-b418-4b77-aebe-bf0606738e4e

PART 4

Explanations Regarding the Implementation of the Plan	The topic will be studied within the suggested 80-minute lesson period, and the evaluation activities will be carried out to achieve the stated learning objectives.

PART 5

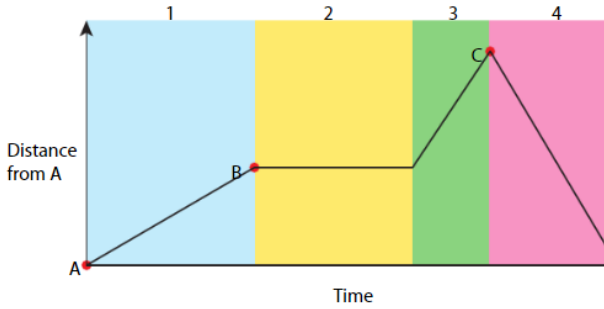
Reflection	

LESSON PLAN 3

PART 1

Course Title	Science
Class	7th Grade
Unit	Unit 3: Forces and energy
Topic	3.3 Describing movement
Time	80 minutes
Date	4 th December 2023
Coursebook	Cambridge Lower Secondary Science Learner's Book 8

PART 2

Learning Objectives	By the end of the lesson the students will: 1. Learn how to use graphs to describe movement. 2. Understand what a distance/time graph shows. 3. Learn to draw a distance/time graph.
Prior Knowledge Required for Students	Students have a foundational understanding of basic graphing concepts, including the interpretation of graphs, the concepts of distance and time, and how these relate to motion.
Unit Concepts and Symbols:	At rest, distance/time graph, safety precautions, sketch, and stationary.
Teaching-Learning Strategies, Methods and Techniques	Question and answer, presentation, demonstration, discussion, experimentation, cooperative learning.
Technology Integration Tools	3D Simulation: https://edu.cospaces.io/Studio/Space/tXCvJ93gX2Ncarvq Interactive Video: https://www.youtube.com/watch?v=lrHAnr9cYdQ
Teaching And Learning Context	Getting started The students will work in groups to answer this question. Imagine you are standing on a path. You start running at a constant speed. What would a line graph look like if you plotted the distance you had run on the vertical axis and the time on the horizontal axis? Main teaching ideas 1. Distance/time graphs A graph is used to depict the relationship between two variables and can be utilized to describe the motion of an object. One approach to achieving this is by plotting a measure of distance on the vertical axis and a measure of time on the horizontal axis. Such a graph is referred to as a distance/time graph.  2. My journey

	In order for students to relate to their own experiences to the construction of a sketch graph, they will think of a journey they recently made. The journey could be coming to school or a longer a journey. They will sketch a distance/time graph for that journey. They will label the graph with what each part represents. 3. Walking and running In this activity, students will plan an investigation, make measurements, do calculations and draw a distance/time graph. The students will calculate the average speed of walking and running in m/s.
Resources	Workbook: 3.3A, Distance/time graphs 1 3.3B, Distance/time graphs 2 3.3C, Distance/time graphs 3
Field Trips / Co-Op / Outings / Lab	Classroom

PART 3

Assessment	Students will answer the questions in the workbook. Kahoot https://play.kahoot.it/v2/*?quizId=9e6d3cd2-089e-448d-8b24-0edfda836224

PART 4

Explanations Regarding the Implementation of the Plan	The topic will be studied within the suggested 80-minute lesson period, and the evaluation activities will be carried out to achieve the stated learning objectives.

PART 5

Reflection	

Numan Musah
Science Teacher

Successful 4/12/2023
Name Surname
School Principal

Appendix 13. Voluntary Participation Form

Voluntary Participation Form

Dear Student,

This study is a master's thesis titled "Technology Integration into Science Teaching-Learning Process: An Action Research." The aim of this study is to investigate the effective integration of technology into the science teaching and learning process. The research is conducted by Musah NUMAN, a student at Anadolu University pursuing an M.A. in Curriculum and Instruction under the supervision of Dr. İnci Zeynep ÖZONAY BÖCÜK and Assoc. Prof. Dr. Çiğdem Suzan ÇARDAK. Within the framework of this study, various technological tools will be employed in the science teaching and learning process. Subsequently, your perspectives, reflections, and behaviors during the science lessons integrated with various technological tools will be observed and collected. Your insights and reflections are highly valuable in exploring effective methods of integrating technology into the science teaching and learning process.

Your participation in this study is voluntary.

- In alignment with the study's objectives, data will be gathered from you through reflection journals, observations, interviews, and questionnaires.
- You are not required to disclose your name or any information that could reveal your identity in the reflection journal and questionnaire.
- Data collected as part of the research will be utilized solely for scientific purposes, will not be utilized beyond the research's scope or in any other study, and will not be shared with others without your written consent.
- Data collected from you will be safeguarded in an encrypted folder on a computer and in a separate folder in the researcher's private library. It will be archived for five years following the conclusion of the research and then securely disposed of.
- During the data collection process, no questions or requests that could cause discomfort will be posed to you. However, should you feel uncomfortable for any reason while responding to questions during interviews, reflections, or questionnaires, you have the right to cease participation without facing any consequences.

Thank you for taking the time to review the voluntary participation form. If you have any questions regarding the study, please feel free to contact Musah NUMAN from Anadolu University, Department of Curriculum and Instruction.

Researcher Name: Musah NUMAN

I hereby acknowledge that the information I have provided will be utilized for scientific purposes by participating in this study of my own volition. I understand that I have the option to withdraw from the study if I so desire.

Participant's Name and Surname:

Signature:

Date:

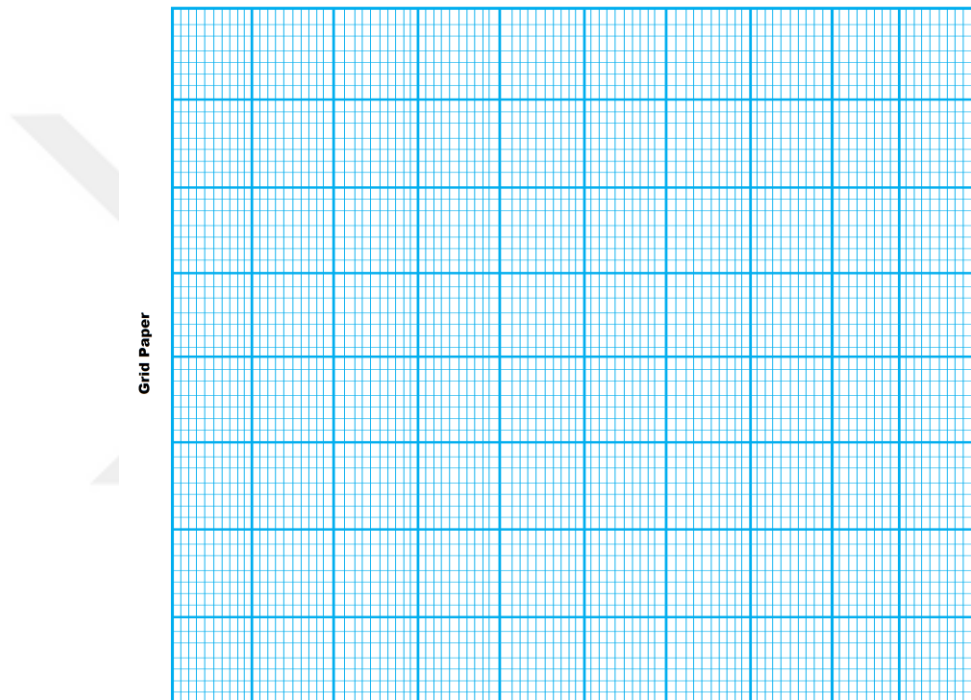
XXXXXXXXXX

Appendix 14. 3D Simulation Worksheet

Complete the following tasks using 3D simulations on CoSpacesEdu

1. Sofia walks from home to a shop at a constant speed. She walks a distance of 10 meters in 10 seconds. She stops at the shop for 5s. She returned home with a constant speed at a distance of 10 meters in 10 seconds.

- a. Sketch a distance/time graph of Sofia's journey from home to the shop and back home.



- b. Calculate Sofia's speed from home to the shop.

[illegible]

a. Sketch a distance/time graph of Marcus' journey from home to his friend's house.

This image shows a full page of white paper with horizontal dotted lines, typical of primary school writing paper. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

CURRICULUM VITAE

Musah NUMAN

Department of Educational Sciences (Curriculum and Instruction)

Master of Arts

Education

Professional Certificate	2023	Google Data Analytics.
Undergraduate	2018	University of Education, Winneba. Ghana. Department of Integrated Science Education
High School	2013	Agona Senior High Technical School. Ghana

Employment

08/2022 - Date	Cambridge Science Teacher	International Gokkusagi Schools, Ankara. Türkiye.
09/2018 – 10/2019	Biology and Science Teacher	Al-Azhariya Islamic Senior High School. Ghana.
09/2017 – 12/2017	Biology and Science Teacher (Intern)	Islamic Senior High School, Ghana.

Publications

Papers Presented at Both National and International Scientific Meetings and Subsequently Published in Proceedings Books

Numan, M. & Özonay Böcük, İ., Z. (2023). Review of Turkish Articles on the Flipped Classroom Model between 2015 and 2022. 11th International Summit Scientific Research Congress December 15-17, 2023 / Gaziantep, Türkiye. (*Presented orally, then subsequently published as full-text articles in proceedings books*).

Numan, M. (2018). *Using Teaching and Learning Materials to Improve the Understanding of Selected Senior High School Students on the Concept of the Circulatory System*. [Unpublished undergraduate project work]. University of Education, Winneba. Ghana.