

TPACK AND INDIVIDUAL INNOVATIVENESS:
A STUDY ON MIDDLE SCHOOL MATHEMATICS TEACHERS IN
TURKEY

by
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ABSTRACT

TPACK AND INDIVIDUAL INNOVATIVENESS: A STUDY ON MIDDLE SCHOOL MATHEMATICS TEACHERS IN TURKEY

This study explores the relationship between middle school mathematics teachers' Technological Pedagogical Content Knowledge (TPACK) and their individual innovativeness. A mixed-methods design was employed, combining correlational and causal-comparative analyses with qualitative interviews. The sample consisted of 130 teachers from public and private schools in Istanbul. Data were collected using the TPACK Scale (Kabakçı Yurdakul et al., 2012) and the Turkish version of the Individual Innovativeness Scale (Kılıçer&Odabaşı, 2010).

Quantitative findings revealed a strong positive correlation ($r \approx .63$) between TPACK and innovativeness, suggesting that more innovative teachers display greater technological pedagogical integration. Gender differences were not significant, but teaching experience was influential. Teachers with more than 20 years of experience reported lower TPACK and innovativeness scores compared to those with fewer years of service.

In the qualitative phase, four teachers with varying TPACK and innovativeness levels were interviewed. Thematic analysis identified five themes: institutional budget, technology ownership, device update frequency, internet application use, and internet usage habits. These findings indicate that technology integration is shaped not only by individual capacity but also by institutional support, resource access, and motivational factors.

The study emphasizes the need for systematic professional development and well-structured in-service programs to enhance teachers' ability to integrate digital tools effectively into mathematics instruction.

ÖZET

TPAB VE BİREYSEL YENİLİKÇİLİK: TÜRKİYE’DE ORTAOKUL MATEMATİK ÖĞRETMENLERİ ÜZERİNE BİR ÇALIŞMA

Bu araştırma, ortaokul matematik öğretmenlerinin Teknolojik Pedagogik Alan Bilgisi (TPACK) ile bireysel yenilikçilik düzeyleri arasındaki ilişkiyi incelemektedir. İstanbul’daki devlet ve özel okullardan 130 öğretmen çalışmaya katılmış, veriler TPACK Ölçeği (Kabakçı Yurdakul vd., 2012) ve Bireysel Yenilikçilik Ölçeği’nin Türkçe uyarlaması (Kılıçer&Odabaşı, 2010) ile toplanmıştır.

Nicel bulgular, TPACK ile yenilikçilik arasında güçlü bir pozitif ilişki ($r \approx .63$) olduğunu göstermektedir. Cinsiyet farklılık yaratmazken, kıdem önemli bulunmuştur. Özellikle 20 yıl ve üzeri deneyime sahip öğretmenler, daha düşük TPACK ve yenilikçilik puanları rapor etmiştir.

Nitel aşamada TPACK ve yenilikçilik düzeyleri farklı dört öğretmenle yapılan görüşmeler sonucunda beş tema belirlenmiştir: kurumsal bütçe, teknoloji sahipliği, cihaz yenileme sıklığı, internet uygulamaları kullanımı ve internet alışkanlıkları. Bulgular, teknoloji entegrasyonunun bireysel kapasitenin yanısıra kurumsal destek, kaynak erişimi ve motivasyonel faktörlere bağlı olduğunu ortaya koymuştur.

Sonuç olarak, öğretmenlerin dijital araçları derslerine etkili biçimde entegre edebilmeleri için sistematik hizmetiçi eğitim ve yapılandırılmış mesleki gelişim programlarının gerekliliği vurgulanmaktadır.

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LIST OF ABBREVIATIONS

CK	Content Knowledge
CODAP	Common Online Data Analysis Platform
II	Individual Innovativeness
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
TCK	Technological Content Knowledge
TK	Technological Knowledge
TPK	Technological Pedagogical Knowledge
TPACK	Technological Pedagogical Content Knowledge

1. INTRODUCTION

Rapid technological advancements have significantly influenced various aspects of education, including mathematics's teaching and learning processes. Technology integration into mathematics education has become essential for fostering students' engagement, enhancing conceptual understanding, and developing problem-solving skills (Brackett, 2024; Shulman, 1986). As education systems globally strive to prepare students for the demands of the 21st century, the role of teachers in effectively utilizing technological tools has gained increasing prominence (Durak, 2021). Teachers are expected to use their content knowledge, their teaching methods, and technological abilities so that lessons can be more meaningful and engaging (Koehler & Mishra, 2009).

Technological Pedagogical Content Knowledge (TPACK) is a key aspect to comprehend the abilities and knowledge when teachers use technology in their lessons. Technological pedagogical content knowledge (TPACK) framework highlights the importance of understanding of content, pedagogy, and technology by teachers. And it also reveals the essence of balanced intersection in teaching (Koehler & Mishra, 2009). TPACK framework also helps mathematics teachers to carry out new ways when learning especially abstract concepts through using dynamic, and visual tools (Chai et al., 2013).

TPACK is crucial for teaching mathematics, but the way teachers use and accept technology in their classrooms also depends on their acceptance of new ideas or technological tools. Individual innovativeness is a crucial factor in how well teachers use technology in their lessons (Rogers, 2003). Teachers with higher individual innovativeness tend to try new ways of teaching, use new technology, and provide an engaging learning environment (Hughes, 2005; Lee et al., 2018).

1.1. Background of the Problem

Internet networks and smart boards are now widely used in twenty-first-century classrooms. This means that teachers need to know the effective methods of using technology to help their students learn. Teachers are important for providing the ideal

learning environment. Therefore, teachers need to know how to use technology effectively in their teaching. If teachers do not know how to use technology effectively, it can be difficult for them to achieve their academic goals in today's education system. Many teachers still use the teaching methods they adopted when they were students. Moreover, these methods may be completely independent of the advancement of technology today.

Teachers face many challenges when they try to use technology without sufficient knowledge. To overcome these challenges, teachers need professional development opportunities specifically designed for their subject areas. Educators need to collaborate with colleagues and attend workshops, seminars and conferences on integrating technology into the classroom. The Ohio Learning Network exemplifies a professional learning community that facilitates discussions among educators regarding the integration of technology in the classroom. This increases their confidence and capacity to overcome emerging challenges (Keengwe&Onchwari, 2011).

In order to use technology tools effectively in the classroom, teachers need to learn these tools in the educational setting. Koehler and Mishra (2006) suggest that programmes that help teachers to use technology better in the classroom help them to better understand the methods of using technology effectively. This means offering teachers the time, tools, and chances they need to get better at what they do.

It is useful for teachers to receive training while working. Thus, they can learn new ways of using technology in the classroom with application opportunities. Also, university programmes that prepare students to become teachers need to teach them the effective use of technology in the classroom. This is an issue that future teachers need to learn more about and get better at in order to cope with the problems that occur in technology-enhanced classrooms (Anthony & Clark, 2011).

1.2. Purpose of the Study

This study examines the relationship between Technological Pedagogical Content Knowledge (TPACK) and individual innovativeness (II) of middle school mathematics teachers working in Istanbul. The study also aims to find out whether there is a significant

difference between mathematics teachers' TPACK and individual innovativeness depending on their gender and the years of teaching experience. The aim of these comparisons is to show how teachers' ability to use technology and individual innovativeness vary according to teaching experience in years and gender.

Moreover, another goal of the study is the examination of the use of digital tools such as GeoGebra and Codap in terms of the perceptions mathematics teachers have in the mathematics education. In addition, investigation of institutional support in technology use and innovative teaching practices is the aim of the study.

1.3. Significance of the Study

1.3.1. Addressing the Need for Technology Integration

This study examines the relationship between teachers' Technological Pedagogical Content Knowledge (TPACK) and their individual innovativeness (II). Today's education requires going beyond the traditional methods to follow the current development. The use of technology in education strongly structures the learning environment and enhances the activeness and exploration phases. Investigation of reflections about technology use and instructional support of mathematics teachers with high and low TPACK and II can draw attention to the factors in the personal and school context in the integration of the technology.

1.3.2. Enhancing Conceptual Understanding Through Tools

The study reveals the mathematics teachers' experiences with the use of digital tools, which are GeoGebra and Codap, in mathematics education and the implications on the effectiveness of the lessons. Rakes, Fields, and Cox (2006) demonstrated that appropriate use of digital tools in education plays a crucial role in enhancing higher-order thinking and metacognitive abilities. So, examining the practical use of the technology by using reflections of mathematics teachers can demonstrate the insights about the complex intersection of the internal and external factors and effectiveness of the use of digital tools in mathematics education.

1.3.3. Implications for Professional Development

This work has implications for programmes that help professionals develop. The results show how TPACK and innovativeness work together. It can also help in planning educational programmes that encourage technological use and innovation. Professional development programmes can help teachers better cope with emerging issues regarding technology. Thus, teachers try to make the most of the advantages of technology (Graham et al., 2019; Phillips et al., 2017). Voogt et al. (2013) emphasise that professional learning communities can help teachers learn more about technology.

1.3.4. Contribution to the Broader Literature

Finally, this study focused on middle school mathematics teachers working in public and private schools. Thus, it contributes to current research on the relationship between technology and innovativeness in mathematics teachers. The results of this qualitative study can be used as a resource for further research on how teachers' characteristics related to technology and innovativeness modify the use of technology in the classroom. Furthermore, examining new structures in education may be important for policymakers, school leaders, and teachers because it provides useful recommendations for forming an educational team that is both technologically savvy and innovative (Timperley et al., 2007). Zhang and Yin (2022) note that focusing on teachers' characteristics may ensure that educational reforms are sustainable over time.

So the aim of this study is also to identify the contexts in which working mathematics teachers can most effectively use technology and new ideas to improve their skills in these areas. Thus, it aims to bridge the gap between theory and practice. Ultimately, the research is important for improving the quality of mathematics education and preparing students for success in an increasingly digital and complex world.

1.4. Research Questions

So, the goal of this study is to answer the following research questions:

1. Is there any statistically significant relationship between in-service middle school mathematics teachers' techno-pedagogical content knowledge (TPACK) and their individual innovativeness characteristics?
2. Do in-service middle school mathematics teachers' techno-pedagogical content knowledge (TPACK) and individual innovativeness characteristics differ significantly by gender?
3. Do in-service middle school mathematics teachers' techno-pedagogical content knowledge (TPACK) and individual innovativeness characteristics differ significantly based on their years of teaching experience?
4. How do in-service middle school mathematics teachers integrate digital tools like GeoGebra and CODAP into their teaching, and does this integration reflect their TPACK or innovativeness levels?
5. How do in-service middle school mathematics teachers reflect on the effectiveness of institutional support in enhancing their use of current technological tools and innovative teaching practices?

1.5. Hypothesis

The following hypothesis guides this study:

- **H1:** A positive correlation exists between in-service middle school mathematics teachers' Technological Pedagogical Content Knowledge (TPACK) and their individual innovativeness characteristics.
- **H2:** There is a statistically significant difference in in-service middle school mathematics teachers' TPACK and individual innovativeness levels based on gender.
- **H3:** There is a statistically significant difference in in-service middle school mathematics teachers' TPACK and individual innovativeness levels based on years of teaching experience.

2. LITERATURE REVIEW

2.1. The Evolution of Technology in Education

The integration of technology in education has experienced considerable transformation in recent decades. Initially, classroom technology consisted of basic tools like overhead projectors, calculators, and educational television programs, which functioned mainly as supplementary aids (Cuban, 1986). The introduction of personal computers in the 1980s and 1990s prompted schools to investigate computer-assisted instruction, emphasising drill-and-practice programs designed to enhance student learning efficiency (Jonassen, 1996).

The internet's rapid expansion in the late 1990s and early 2000s initiated a transformative period in education, facilitating access to extensive information resources, digital libraries, and online learning environments (Selwyn, 2011). E-learning platforms and learning management systems (LMS) like Moodle and Blackboard have enabled distance learning and transformed teacher-student interactions. This period highlighted the significance of information retrieval alongside collaborative learning facilitated by digital forums, emails, and online communities (Anderson, 2008).

Recent advancements in technologies, including mobile learning applications, interactive whiteboards, cloud-based collaboration tools, and artificial intelligence-supported educational platforms, have significantly altered teaching and learning practices (Voogt et al., 2015). These innovations transformed the role of teachers from mere transmitters of knowledge to facilitators of active, technology-enhanced learning environments. The demand for teachers to acquire new competencies that integrate content expertise, pedagogical strategies, and technological proficiency has increased (Mishra & Koehler, 2006).

The Technological Pedagogical Content Knowledge (TPACK) framework highlights the necessity of integrating technology, pedagogy, and content knowledge to enhance teaching effectiveness (Mishra & Koehler, 2006). In this context, ChatGPT and similar AI-

powered tools are categorised within the Technological Knowledge (TK) domain, as they embody emerging technologies with prospective applications in education.

Recent research has started to position AI tools such as ChatGPT within the framework of TPACK. Kasneci et al. (2023) emphasise that generative AI tools offer opportunities for personalised feedback, idea generation, and content creation; however, their application in education necessitates robust pedagogical framing. Teachers must possess knowledge of tool usage (TK) and comprehend how to integrate them with effective teaching strategies (PK) and subject-specific objectives (CK).

In mathematics education, ChatGPT can facilitate the generation of problem-solving steps, provide explanations, and offer alternative representations of concepts. When integrated thoughtfully, this represents Technological Pedagogical Knowledge (TPK), as educators incorporate AI output into their instructional methods. Moreover, the use of ChatGPT to assist in elucidating particular mathematical concepts demonstrates Technological Content Knowledge (TCK). The effective integration of ChatGPT in classrooms relies on teachers' capacity to combine all three domains, situating it within the TPACK framework (Zawacki-Richter et al., 2019; Holmes et al., 2022).

This evolution highlights the importance of frameworks such as TPACK, which illustrate the interaction among technology, pedagogy, and content knowledge. These models emphasise that successful technology integration in education demands more than mere technical skills; it requires a comprehensive understanding of the meaningful application of technology within particular pedagogical and disciplinary frameworks.

2.2. TPACK Framework

Mishra and Koehler (2006) introduced the Technological Pedagogical Content Knowledge (TPACK) framework. This framework was developed by adding technology to Shulman's (1986) Pedagogical Content Knowledge (PCK) concept. TPACK emphasizes how three main types of knowledge interact in complex ways to contribute to effective teaching in the digital age. These three main areas are listed below.

1. Content Knowledge (CK)
2. Pedagogical Knowledge (PK)
3. Technological Knowledge (TK)

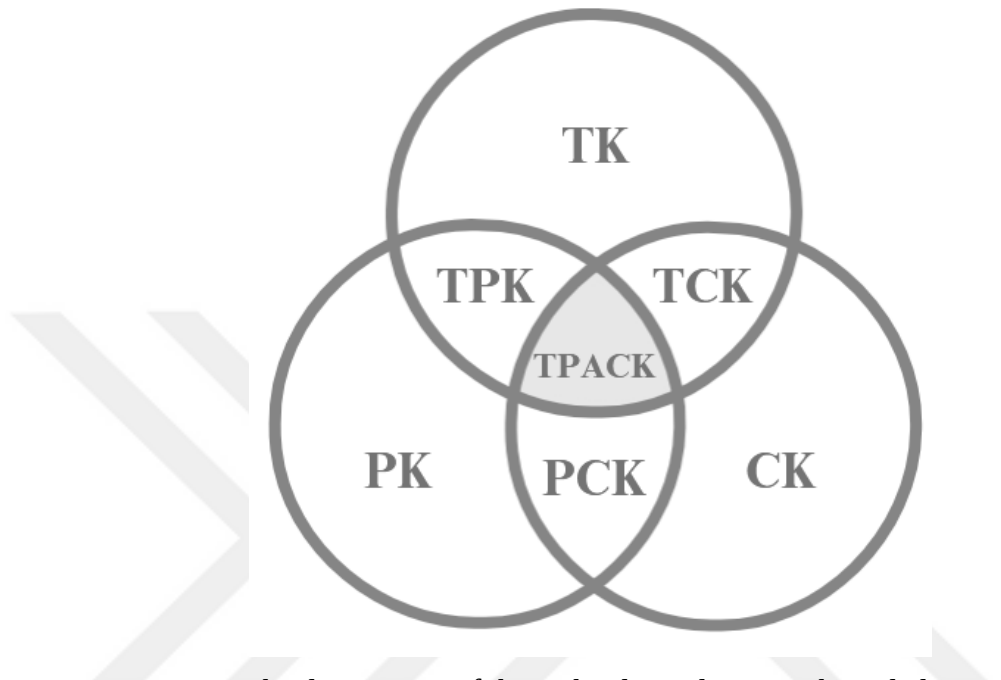


Figure 2.1. The dimensions of the technological content knowledge approach

There are also the intersections of these areas that reveal how they are connected:

- Pedagogical Content Knowledge (PCK)
- Technological Content Knowledge (TCK)
- Technological Pedagogical Knowledge (TPK)
- Technological Pedagogical Content Knowledge (TPACK)

Table 2.1. A general summary of the ideas that form the TPACK framework proposed by Mishra and Koehler (2006).

Construct	Description
TK	Technological knowledge is related to the use of digital tools. This knowledge includes computer use, system operation, software use, use of Word, Excel, browsers, email, and spreadsheets. It also covers technical operations such as updating, installing, or formatting digital tools. (p. 1027)
CK	Content knowledge is about knowing the subject matter to be taught. This knowledge includes the facts, concepts, and theories related to that subject. It also encompasses how information is proven or connected. (Shulman, 1986). (p. 1026)
PK	Pedagogical knowledge is about how people learn. It is closely related to teaching methods. This knowledge also includes classroom management, lesson planning, clarity of instruction, and subsequent assessment methods.(p. 1026–1027).
TCK	Technological content knowledge is the knowledge that demonstrates how technology and content work together. It's about leveraging technology to process content. Technology allows content to be explained more effectively. (p. 1028)
TPK	Technological pedagogical knowledge is knowing how to integrate technology into the learning process. It includes knowledge of different educational technology methods. (p. 1028)
PCK	Pedagogical content knowledge means integrating content and teaching methods. It means knowing how to teach knowledge mastered in a field. PCK provides guidance on how to organize and explain information in the learning process. This knowledge goes beyond simply knowing content and pedagogy separately and involves establishing relationships between them. (p. 1021)
TPACK	Effective technology-assisted teaching is within the scope of TPACK. It is about knowing how to explain the knowledge mastered in the field using the technology. It involves integrating technology and teaching strategies harmoniously. It makes the learning process more effective. It supports students with diverse needs. It plans to shape the learning process based on students' prior knowledge. (p. 1029)

2.2.1. Technological Pedagogical Content Knowledge (TPACK)

TPACK is the intersection of content, pedagogy and technology areas. This model highlights that areas separately are not enough to shape effective education. It focuses on the balance and the relationship between different areas. For example, teachers who have high content knowledge and too limited technology and pedagogy knowledge may not be able to implement effective instruction.

Teachers play a crucial role in maintaining the balance between different areas. Koehler and Mishra (2009) states teachers' role in this intersection is not rigidly restricted. Teachers determine the most appropriate technological tools and methods for the content they will teach and create a designed lesson.

2.2.2. Modern Practical Applications of TPACK in Mathematics Education

2.2.2.1. GeoGebra: Interactive Tools for Geometry and Algebra. GeoGebra application is a dynamic application that allows students to learn interactively. Thanks to GeoGebra, teachers and students are able to explore mathematical concepts in a visual manner. Providing the relationship between content, technology and pedagogy can be balanced through GeoGebra. Therefore, it is highly compatible with the Technological Pedagogical Content Knowledge (TPACK) framework. GeoGebra contains contents that can be used in middle schools. GeoGebra is also popular because it has no time or place restrictions and is free (Furner & Furner, 2012). Geogebra can be integrated into various educational settings and methods from traditional approaches to the constructivist ones. GeoGebra is also suitable for differentiated education because it can be personalized based on user preferences (Preiner, 2008). In addition to that, GeoGebra is appropriate for collaborative learning as multiple users can edit at the same time (Hohenwarter&Lavicza, 2007).

Furthermore, it can make connections between different mathematical constructs. For example, users can interactively alter the symbols and examine the change in graph version in the same screen. It can motivate students by visually representing various mathematical concepts and the relationships between them in a dynamic way (Guncaga&Majherova, 2012). Building connections among different representations enhances cognitive and reasoning abilities (Dikovic, 2009).

The Geogebra program is a very useful and practical tool for teachers to create their own teaching materials (Preiner, 2008). Therefore, teachers can integrate the application based on students' profile, content or teaching methods.

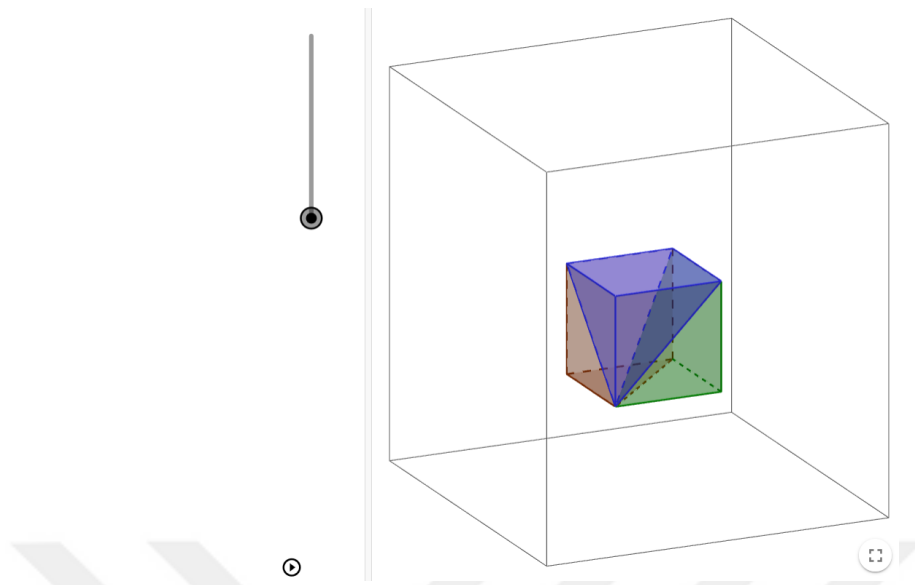


Figure 2.2. A GeoGebra illustration.

The application is useful for developing spatial reasoning. Users can manipulate the variables and 3D shapes like in Figure 2.2.

Ronau et al. (2009) indicates that an instruction design which is integrated with GeoGebra activity by taking account of the TPACK framework enhances the students' self regulation at the end of the learning process.

2.2.2.2. CODAP. The Common Online Data Analysis Platform (CODAP) was developed by the Concord Consortium. It is a free website that visualizes data analysis and allows users to control variables.

It allows for simple operations like calculating the mean and median mode, as well as exploring higher-level data properties like correlation. It is preferred by users due to its easy-to-use interface and lack of time and space constraints. Teachers can integrate CODAP into their lesson plans based on the content they will cover, student profiles, and activities they will implement.

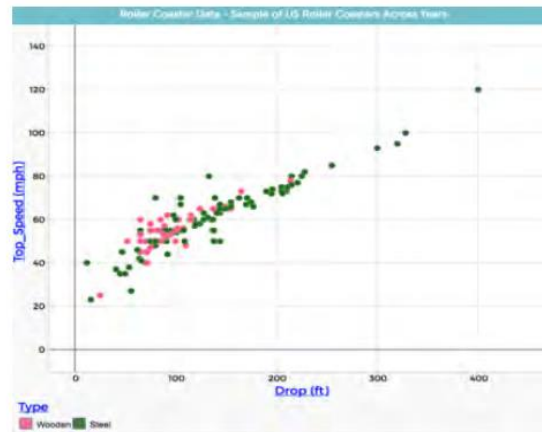


Figure 2.3. CODAP illustration.

Lee and Dubovi (2020) emphasize the importance of learning how to interpret data that people encounter in daily life. Finzer (2016) emphasized that data is one of the most important factors in decision-making in today's world and highlighted that CODAP has a structure that allows users to ask questions, explore and interpret in this context.

Frischemeier et al. (2021) examined the use of Codap in a high school mathematics course. Based on the results, Codap was quite helpful for students in simple and intermediate data analysis, but that using other high-level applications would be more beneficial for larger and more advanced datasets. Engel et al. (2018) asserted that CODAP helps to construct decision tree plugs interactively. Biehler et al. (2020) emphasized that the CODAP application is an online platform where users can personalize according to their own needs, but its ability to handle high-level operations like decision tree plug is limited.

Based on the study, CODAP helps students think more critically and analyse data better. CODAP's design visualises patterns, trends, and relationships in data sets, as stated by Finzer (2019). This approach is consistent with constructivist teaching approaches. To illustrate, it enables students to learn by discovering data. CODAP helps students learn basic statistical concepts such as median, mean, distribution, correlation, and others (Wilkerson & Polman, 2020).

The CODAP interface is intuitive and interactive. Data are structured in dynamic tables that allow for straightforward manipulation, while visualisations, including histograms, scatterplots, and boxplots, can be generated through intuitive drag-and-drop actions. A notable characteristic is the integration of multiple representations: selecting a data point in one display results in its automatic highlighting across all other graphs and tables. This interactive design enables students to establish significant connections among various forms of representation, thereby enhancing their conceptual understanding.

As a result, the CODAP application has a structure that can be adjusted based on different student types. Also it is a useful tool for constructivist education that supports the active participation of students and supports teachers' TPACK skills. However, its competence is limited for very high-level data

2.2.3. TPACK Framework in Educational Research

2.2.3.1. TPACK Development in Preservice and in-Service Teachers. Researchers have examined preservice teachers' relationships with characteristics of TPACK in teacher education programmes. Cavin (2008) conducted a microteaching study with teacher candidates. It has been demonstrated that structured microteaching activities significantly develop their TPACK. Özgün-Koca et al. (2010) conducted a qualitative study with mathematics teachers. The aim was to create teaching materials using technology in real classroom settings. Another study showed that teachers with practical experience in digital tools were able to use technology more effectively in their lessons. Akkaya (2009) wanted participants to design lesson plans on the concept of derivatives and conduct microteaching applications. Significant progress was made in the areas of Content Knowledge (CK) and Pedagogical Content Knowledge (PCK). The findings emphasise the need to incorporate TPACK-focused education into teacher education programmes.

While many studies focus on teacher candidates, researchers have also examined the TPACK development of practising teachers through professional development programmes. González and Bravo (2024) conducted a systematic review focusing on the TPACK perceptions of middle school teachers who worked between 2017 and 2022. The review revealed limited development in the areas of content knowledge (CK) and

pedagogical knowledge (PK), while significant development was observed in the area of technological knowledge (TK). This suggests that they often struggle to use them effectively in the classroom.

2.2.3.2. Studies about TPACK in Mathematics Instruction. Knight (2007) and McGatha et al (2018) asserted that mathematics coaching enhances teachers' TPACK. Kartal (2017) revealed that self-esteem and belief significantly affect their use of technology and TPACK in mathematics education. Patahuddinet al.(2016) and Tang and Zhang (2021) assert that mathematics teachers' TPACK enhancement is limited in the international setting. Macakoğlu (2017) showed that the mathematics teachers' TPACK did not show a significant difference based on the gender variable, but showed a significant difference based on whether they had their own computer. Similarly, Bilgiç (2022) found that preservice primary school mathematics teachers' TPACK scores did not differ significantly based on gender and undergraduate year.

Grandgenett (2008) drew attention to the role of mathematics teachers for effective design which increases academic success. The study highlights the balancing technology, pedagogy and content in a conscious way plays a crucial role in mathematics teaching. Similarly, Guerrero (2010) demonstrated that lessons prepared with TPACK increased students' interest in the lesson, motivation and self-confidence.

Akkaya (2009) study stated that there was a significant difference in the TPACK items that mentioned student-related difficulties as a result of the training given to mathematics teachers. Archambault and Barnett (2010) stated that the TPACK framework in geometry education provides guidance for teachers to blend pedagogy, content and technology harmoniously. Saralar (2016) found that a significant difference was observed in the TPACK scores of preservice primary school mathematics teachers after the practice course they took.

Sarı and Bozkurt (2021) suggested that instead of focusing on the frequency of technology use, giving importance to the balance between pedagogy and technology use can be more crucial for effective mathematics education. Niess and Garofalo (2006) recommended that mathematics teachers should first experience the learning process as

students in order to increase their TPACK scores, since it is claimed that mathematics teachers teach based on their own experiences.

In short, studies show that mathematics teaching and TPACK are closely related. While no significant difference is generally detected based on demographic data, it is emphasized that environmental factors and facilitations can affect teachers' TPACK scores in a meaningful way. In addition, it is emphasized that the training that mathematics teachers receive can ensure that they provide balance between technology, content and pedagogy in their lessons.

2.3. Innovativeness

According to Rogers (2003) in his Diffusion of Innovations Theory, innovativeness refers to the willingness and capacity of individuals to adopt and implement new ideas, methods, or technologies. This trait is essential for educators, particularly mathematics instructors, who must maintain rigorous academic standards while adapting to evolving teaching methodologies and technological advancements.

2.3.1. Characteristics of Innovativeness Framework

Rogers' theory identifies five key factors—relative advantage, compatibility, complexity, trialability, and observability—that influence the acceptance of innovations. The characteristics significantly influence mathematics teachers' perceptions and the integration of instructional changes, thereby enhancing student learning experiences and outcomes.

Table 2 presents a summary of these characteristics, including their descriptions, potential applications in mathematics education, and relevant literature references.

Table 2.2. Overview of characteristics of Innovativeness Framework as proposed by Rogers (2003).

Characteristics	Description	Application in Education (Focus on Mathematics Teachers)	References
Relative Advantage	The perceived benefit of adopting an innovation compared to current methods or practices.	Educators may employ dynamic geometry software if it improves student understanding beyond traditional methods.	Rogers (2003); Hwang & Chang (2020)
Compatibility	The degree to which the innovation aligns with existing values, requirements, and practices.	The adoption of technology, including graphing tools, is more likely when it aligns with curriculum standards and educational objectives.	Rogers (2003); Kaya & Aydın (2021)
Complexity	The intricacy of innovation regarding understanding and user-friendliness.	Educators may refrain from utilizing complex AI-driven tools if they perceive them as difficult to implement or necessitating significant training.	Rogers (2003); Nguyen & Smith (2021)
Trialability	The degree to which the innovation is subject to testing or experimentation prior to full-scale implementation.	Educational institutions that implement pilot programs for innovative technologies, such as virtual laboratories, increase the likelihood of adoption by mathematics educators.	Rogers (2003); Tóth et al. (2019)
Observability	The visibility of the innovation's outcomes demonstrates its effectiveness.	Educators are more likely to adopt peer-reviewed instructional strategies upon witnessing measurable improvements in student performance..	Rogers (2003); Öztürk & Çakıroğlu (2022)

2.3.2. Categories in the Diffusion of Innovations Model

The categories presented in the Diffusion of Innovations Model (Rogers, 2003) demonstrate the varying rates at which different groups adopt a new idea, product, or innovation over time. The categories illustrate the adoption process among a population.

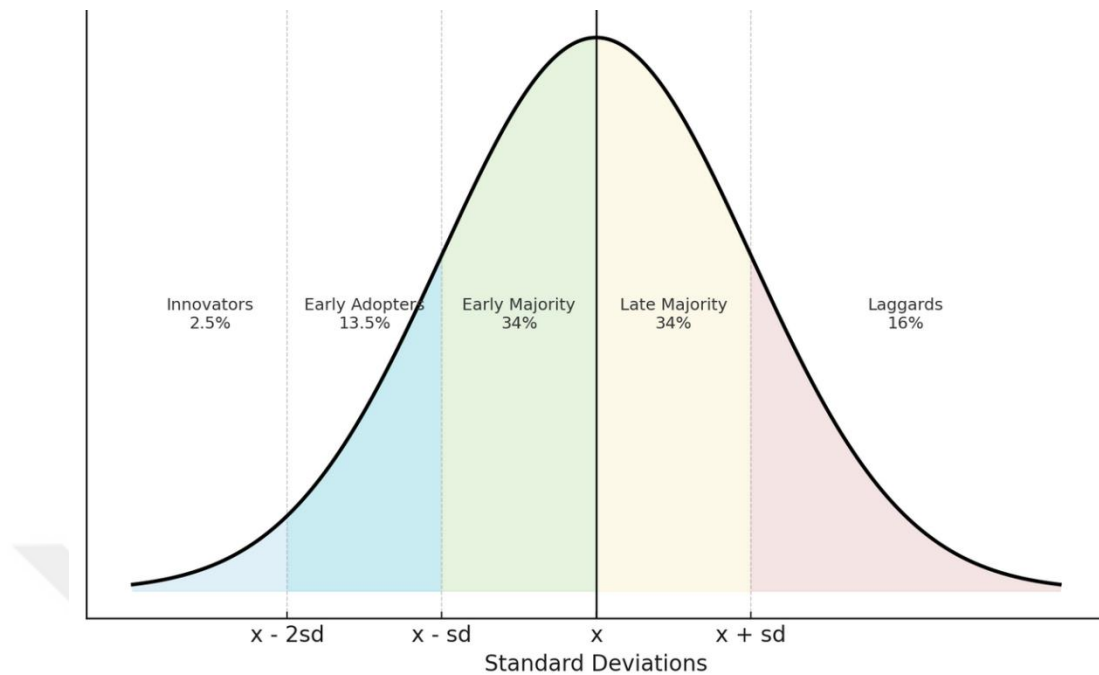


Figure 2.4. Categories in the diffusion of innovations model (Rogers, 2003).

Innovators (2.5%): Innovators constitute the initial cohort of individuals who adopt an innovation. They demonstrate risk-taking behavior, hold advanced degrees, and possess financial resources. Their inclination towards experimentation and risk-taking is essential for the introduction of new ideas (Rogers, 2003).

Early Adopters (13.5%): This group demonstrates increased caution compared to innovators while maintaining substantial influence within social systems. Early adopters often serve as opinion leaders, shaping the attitudes and behaviors of others towards innovation. They are crucial for creating momentum during the early stages of adoption (Rogers, 2003; Valente, 1996).

Early Majority (34%): The early majority, representing 34% of the population, adopts innovations in a more measured manner. They lack leadership qualities and are instead influenced by their social network. The adoption by this group is crucial for innovation to attain widespread use and transition into the mainstream (Kılıçer, 2011; Özgür, 2013; Rogers, 2003).

Late Majority (34%): The late majority, representing 34% of the population, displays skepticism and typically adopts innovations only after the majority of their peers have accepted them. Decisions are often shaped by economic necessity or social pressure instead of intrinsic motivation (Rogers, 2003).

Laggards (16%): This group constitutes the last segment to adopt innovation, often demonstrating resistance to change and a strong inclination towards traditional methods. Individuals typically remain isolated within their social networks and are inclined to embrace innovations only when such changes are deemed necessary (Rogers, 2003).

Laggards are individuals who exhibit the slowest inclination to adopt innovations. Their adherence to traditions results in a prolonged adoption of innovations. They exhibit a bias against innovations. Individuals in the aforementioned categories are anticipated to engage with innovations and achieve successful outcomes due to their aversion to risk-taking. Laggards require substantial assistance with technology, and their social communication is limited. Consequently, they tend to seek innovations from individuals they trust significantly, utilizing face-to-face communication (Beal & Bohlen, 1956; Kılıçer, 2011; Özgür, 2013; Rogers, 1995).

2.3.3. Innovation in Education

Innovation in education has become a crucial element in meeting the evolving requirements of 21st-century teaching and learning. The process entails the deliberate implementation of novel concepts, methodologies, instruments, or strategies aimed at enhancing educational practices and outcomes (OECD, 2016). In modern educational settings, innovation extends beyond technological integration; it includes pedagogical transformations, curriculum reconfigurations, and the establishment of novel teacher-student interactions (Fullan, 2013).

Ritchhart (2004) characterizes an innovative teacher as a professional who engages in self-development, creates subject activities aligned with the curriculum, employs novel approaches and methods for presenting information, enhances student participation through diverse methodologies, and acquires new skills by modifying established habits.

Educators play a central role in driving educational innovation. Their readiness to embrace new methodologies, undertake instructional risks, and participate in reflective practices significantly impacts the implementation and sustainability of innovative approaches (Baran, 2010). Şahin (2011) indicates that innovative teachers typically exhibit characteristics including openness to change, creativity, and a proactive attitude, facilitating their adaptation to evolving educational demands and technological progress. These characteristics enhance both their professional development and the overall learning experience of their students.

Zhu et al. (2013) highlight that innovation is a process underpinned by ongoing professional learning, experimentation, and collaboration. Educators who adopt innovative practices typically engage in continuous professional development, investigate various instructional strategies, and collaborate with colleagues to exchange experiences. These actions facilitate the development of competencies essential for student-centered learning environments that prioritize creativity, critical thinking, and problem-solving.

Institutional culture significantly influences the promotion or obstruction of innovation. Supportive school leadership, resource accessibility, encouragement for experimentation, and diminished fear of failure are critical factors that foster teacher innovation (Kılıçer&Odabaşı, 2010).

2.4. The Relationship between Innovativeness and TPACK in Mathematics Education

Ngafeeson and Sun (2015) stated that students with high innovativeness tended to be more likely to accept technology towards using e-textbooks. The researchers claimed that technological innovation is coextensive with personal innovation in this study. Similarly, Teo (2009) emphasizes that the effective use of technology in learning and teaching depends on how teachers accept it. Daud and Zakaria (2017) examined how academic researchers at research universities in Malaysia use collaboration technologies. Based on the results of the study, personal innovation is a pivotal component of using collaboration technologies.

According to a study conducted by Yenice and Yavaşoğlu (2018) with 159 science teacher candidates who were enrolled in an education faculty, science pre-service teachers were classified as explorers who have moderate scientific innovation. Research has shown a strong correlation between innovation and technology. As stated by Rosen (2005), Agarwal and Prasad (1998), innovation affects the relationship between attitudes towards new technology and the intention to use it.

Kılıçer (2011) conducted a study aimed at determining the innovation profiles of teacher candidates in the Computer and Instructional Technologies Education Department and the situations they perceived as barriers to innovation. The analysis of the research data revealed that two-thirds of computer teaching education departments were at a high or medium level of innovation, one-third were at a low level of innovation, and 88.60% were in categories considered good/above average in terms of innovation, with the majority falling into the questioning category. Based on Koh, Chai, and Tsai (2022), teachers who score higher on TPACK are more competent and confident when integrating innovative teaching strategies. Similarly Öztürk and Çakıroğlu (2022) found that teachers with higher TPACK competence were more likely to use student-centred, inquiry-based, and technology-using teaching methods. Their research showed that TPACK can be used as both a theoretical framework and a practical foundation for promoting new ideas in mathematics education.

In conclusion, individual innovativeness of preservice or in-service teachers and their ability to adopt instructional innovations are positively and significantly correlated, according to a significant portion of those studies (Haelermans & Blank, 2012; Çuhadar, Bülbül & Ilgaz, 2013; Gökçearslan, Karademir & Korucu, 2016; Orun, Orhan, Dönmez & Kurt, 2015; Yılmaz & Bayraktar, 2014).

2.5. Systemic, Institutional, and Cultural Influences on TPACK-Driven Innovation

Although the advantages of incorporating TPACK into teaching methodologies are well-established, various systemic, institutional, and cultural obstacles impede its broad implementation. Rigid curricula, centralized assessments, time constraints, and limited access to technological resources constitute substantial obstacles, especially in low-

resource contexts (Kaya & Aydın, 2021; Ertmer & Ottenbreit-Leftwich, 2010; Smith & Brown, 2020). In Turkey, educators frequently indicate a desire to innovate; however, they perceive a lack of support from institutional policies and leadership structures (Nguyen et al., 2021).

Professional development plays a crucial role to enhance teachers who are able to provide balanced content, pedagogy and technology knowledge despite challenges. Niess (2011) revealed that the professional development project increased the TPACK scores of the mathematics teachers. Similarly, Shin et al. (2009) emphasized that in-service training increased teachers' TPACK scores. Harris and Hofer (2011) showed that a professional development project on the use of TPACK in education improved teachers' lesson plans and teaching quality.

Ince (2015) demonstrated that middle school mathematics teachers have the components of TPACK separately, but they have difficulty in combining the components within the same course. Professional development programs were suggested to enhance teaching quality in solving this problem. Benning (2021) revealed that as a result of the professional development program designed using GeoGebra, teachers' success in creating a mathematical discussion environment, making connections, and the quality of assessment enhanced.

In summary, external factors such as school environment, financial support, and student profile, as well as internal factors such as teachers' attitudes, technological, content, and pedagogical knowledge, and their ability to use digital tools shape mathematics education. Professional development can be crucial to positively enhance these factors in mathematics education.

3. METHODOLOGY

Chapter 3 includes the design of the study, population and sample, data collection, data collection procedure, and data analysis

3.1. Design of the Study

The study includes a sequential explanatory mixed methods design. Firstly, correlation and causal-comparative design were used for the quantitative aspect. In the correlation design, the relationship between TPACK and individual innovation characteristics of middle school mathematics teachers was examined. In the causal comparative design, it was examined whether there is a significant difference in TPACK and individual innovation characteristics of middle school mathematics teachers based on gender and teaching experience years. In the qualitative part of the study, semi-structured interviews were conducted. Mathematics teachers' experiences and reflections regarding institutional support and the use of digital tools were examined.

A mixed-methods design provides a combination of quantitative and qualitative views, which helps to better understand the research problem (Creswell, 2007). Quantitative methods give statistical data and make it easier to determine conclusions that can be generalized to other situations. However, they may not fully capture the emotional, contextual, and experiential aspects of how teachers act (Creswell, 2014). In this point, qualitative methods give a full and in-depth look at these aspects (Denzin & Lincoln, 2018). The goal of this study is to combine the important parts of both approaches

In conclusion, this study used a mixed-methods framework that is mostly quantitative, with supportively qualitative insights to explain, and improve the interpretation of the main quantitative results.

3.2. Population and Sample

3.2.1. Quantitative Sample

To make sure the study was possible and relevant to the situation, the quantitative sample was limited to in-service middle school math teachers in Istanbul, Turkey's most populous city, which has a wide range of educational settings.

According to the Istanbul Provincial Directorate of National Education (MEB, 2024), there are about 4,379 mathematics teachers working in public and private middle schools in Istanbul. This number helps to determine how many people the study can reach.

There are many different kinds of schools and levels of education in Istanbul. Some are very good and have the latest technology, while others have to work with less facilitations. This variety gives us a good way to look at how teachers' TPACK and levels of innovation vary in different institutional settings.

The criteria of Cohen (2007) for finding a medium effect size ($r = 0.30$) with $\alpha = 0.05$ and power = 0.80 say that a sample size of at least 100 people is enough for statistical analysis. The planned number of people in the sample is between 100 and 150. Some people may give careless or wrong answers. Therefore the scales include reverse-coded items that find and remove these answers.

The sample included teachers of both genders, aged 23 and up, who work in both public and private schools. This sampling method makes sure that all important demographic factors, such as gender, age, and type of school, are represented. This is important for looking at possible differences in TPACK and levels of innovation.

The target group is middle school math teachers who work in public and private schools in Istanbul. The number of participants for this group of people was 130.

Table 3.1. Frequency and percentage of participants by gender, teaching experience, and school type.

Variable	Category	n	%
Gender	Female	67	51.5%
	Male	63	48.5%
Teaching Experience	0–10 years	45	34.6%
	11–20 years	44	33.8%
	20+ years	41	31.5%
School Type	Public	90	69.2%
	Private	40	30.8%

Note. N = 130.

The sample consisted of 130 in-service middle school mathematics teachers in İstanbul. 51.5% of these participants were female ($n = 67$) and 48.5% of the sample were male ($n = 63$). In terms of teaching experience, 34.6% of the sample ($n = 45$) reported having 0–10 years, 33.8% of it ($n = 44$) had 11–20 years, and 31.5% of it ($n = 41$) have over 20 years of teaching experience. About school type, while 30.8% ($n = 40$) of the participants worked at private schools, 69.2% ($n = 90$) of the sample worked at public schools.

3.2.2. Qualitative Sample

In the study's qualitative phase, four middle school mathematics teachers who are currently working were chosen through purposive sampling. Participants were selected from participants who completed the quantitative survey and consent is provided for the interview phase. The selection provides diversity in school type (public versus private) and levels of TPACK/innovativeness (high versus low).

This sampling strategy aims to include diverse and contrasting perspectives, providing deeper insights into the links between institutional settings and personal characteristics on technology integration and instructional innovation.

- All participants are currently employed as middle school mathematics teachers in İstanbul.
- Be aged 23 and above,

- Two participants were from public schools, while the other two were from private schools.
- Selection was based on scores in the TPACK and Innovativeness scales, categorized as high or low.

Table 3.2. Characteristics of the qualitative sample.

Participant Code	School Type	TPACK & Innovativeness Level
P1	Public	High
P2	Public	Low
P3	Private	High
P4	Private	Low

3.3. Sampling Strategy

3.3.1. Quantitative Sampling Strategy

A non-probability convenience sampling method was used for the quantitative phase. The participants included in-service middle school mathematics teachers employed at public and private schools in Istanbul. This approach was selected due to the researcher's lack of access to a comprehensive population list, with participation relying on voluntary responses to an online survey.

The convenience sampling method facilitates data collection from numerous participants within a constrained timeframe and practical limitations. The survey was disseminated digitally via professional networks, institutional email lists, and educator communities on social media platforms. This method, while limiting generalizability, is appropriate for exploratory studies investigating correlations between variables like TPACK and innovativeness in terms of time and practicality.

Reverse-coded items were employed to identify inattentive responses, thereby ensuring data quality. The anticipated sample size was between 100 and 150, necessitating at least 100 valid responses for statistical analysis. The study had 130 middle school mathematics teachers who were currently working.

3.3.2. Qualitative Sampling Strategy

Four mathematics teachers of the participants who participated in the quantitative survey and accepted to take part in the qualitative phase were selected using a purposive sampling strategy. The goal of this strategy is to provide a range of perspectives based on important factors like the type of school (public vs. private) and the levels of TPACK and individual innovativeness (high vs. low).

This contrasting variation strategy provides that a broad range of experiences are investigated. So it makes the study easier to look into individual and contextual factors and how teachers use technology in their classrooms. There were two public school teachers in the qualitative sample. One had high TPACK/innovativeness levels and the other had low levels. Also, two teachers from private schools were included, one with high TPACK/innovativeness and the other with low levels.

3.4. Data Collection Tools

3.4.1. Demographic Information Form

The survey starts with a section that collects demographic information about the mathematics teachers who participated. This part helps to collect data to determine differences based on important demographic and professional factors.

The survey includes questions about gender and teaching experience duration . These questions are crucial for investigating if there is a significant difference in TPACK and Individual Innovativeness (II) between male and female participants and between teachers with different amounts of teaching experience.

3.4.2. Quantitative Component

3.4.2.1. Instrument for TPACK.Technological Pedagogical Education Competency Scale, or TPACK-deep Scale [TPACKS], was made by Kabakçı Yurdakul et al. (2012), to test the techno-pedagogical content knowledge of teachers. There are 33 items on the scale, which

are divided into four groups. These are design, implementation, ethics, and specialization. The scale uses a five-point Likert format. They are "I can easily do it," "I can do it," "I can partially do it," "I cannot do it," and "I definitely cannot do it." The lowest score on the scale is 33 and the highest score is 165. Higher scores mean that the individual is better at technological pedagogical education knowledge. The Cronbach's alpha coefficient for the scale's factors is between .85 and .92. The full scale had a Cronbach's alpha coefficient of 0.95, and the test-retest coefficient was 0.80 (Kabakçı Yurdakul et al., 2012). Büyüköztürk et al. (2014) said that values over 0.70 show that survey is very reliable.

3.4.2.2. Instrument for Innovativeness.Hurt, Joseph, and Cook (1977) came up with the Innovativeness Scale so that individuals' ability to accept and embrace new ideas can be measured.

Kılıçer and Odabaşı (2010) adapted the scale for Turkish culture. The Turkish version of the scale demonstrated a Cronbach's Alpha internal consistency coefficient of .82. A test-retest reliability coefficient of .87, and a Spearman-Brown reliability coefficient of .85 for the consistency of the two halves of the scale.

The survey consists of 20-items and four-factor structure, with valid factor configurations. The factors include resistance to change, opinion leadership, openness to innovation, and risk-taking (Kılıçer&Odabaşı, 2010). The lowest score is 20 and the maximum score is 100. Higher scores reflect better at innovativeness and competency.

Individuals who exceeds 80 points are categorized as "Innovative," those with scores ranging from 69 to 80 points as "Pioneer," scores between 57 and 68 points as "Interrogator," scores from 46 to 56 points as "Skeptic," and scores below 46 points as "Traditional" (Kılıçer&Odabaşı, 2010).

3.4.3. Qualitative Component

The interview structure was designed according to the individual innovativeness model proposed by Kılıçer, Bardakçı, and Arpacı (2018), which delineates five essential technology-related characteristics that affect innovativeness. Utilizing this framework, the

researcher formulated original, open-ended questions designed to explore the relationship between these factors and teachers' professional practices, specifically regarding TPACK and institutional opportunities or constraints. The interview aims to explore teachers' perceptions of their ability to adopt and maintain technological innovations in mathematics.

The categories informed the creation of targeted interview questions, crafted by the researcher to capture both individual technology habits and the impact of institutional enablers and barriers on the implementation of these habits within educational settings.

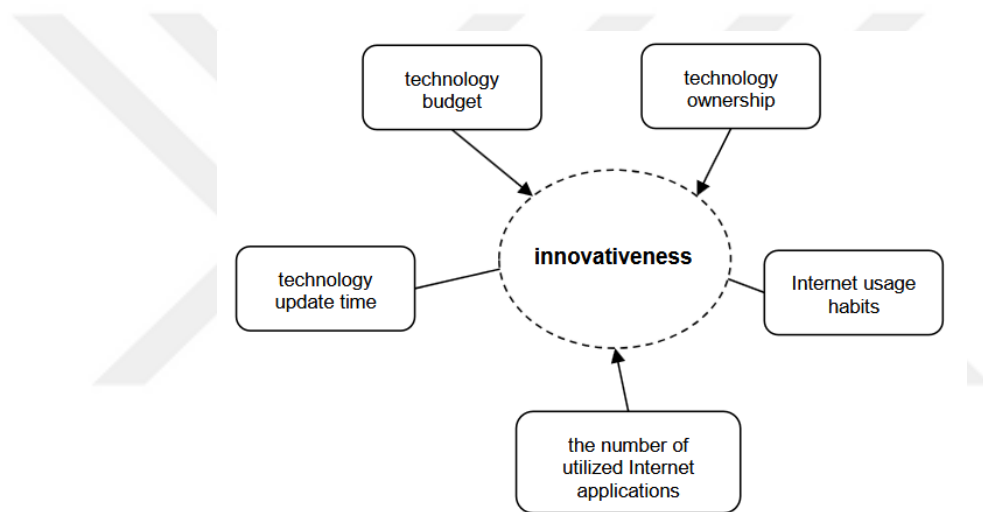


Figure 3.1. Research model (Kılıçer, Bardakçı, and Arpacı, 2018).

The study identifies five primary predictors of innovativeness.

- **Technology Budget:** The financial resources designated for the acquisition and enhancement of technological devices.
- **Technology Ownership:** Technology Ownership refers to the range and number of technological devices possessed by an individual.
- **Update Time for Technological Devices:** The rate at which an individual refreshes or substitutes their technological devices.
- **The Number of Utilized Internet Applications:** The spectrum of Internet-based applications utilized by the individual.

- Internet Usage Habits: The methods, objectives, and regularity of internet engagement.

The interview comprises five sections that examine various components of the research model. The questions were reported in Appendix D and E.

3.5. Data Collection Procedures

3.5.1. Quantitative Component

This study's quantitative data was gathered through an online survey conducted using Google Forms, aimed at in-service middle school mathematics teachers in Istanbul. The survey was divided into three sections: demographic information, the Technological Pedagogical Content Knowledge (TPACK) Scale, and the Individual Innovativeness Scale. The survey is estimated to take approximately 15 minutes to complete.

Participants were notified and invited to engage via social media platforms, teacher email lists, and the researcher's professional network. The study employed a convenience sampling method to collect data from 130 teachers.

3.5.2. QualitativePart

For the qualitative phase, participants were selected from those who have already participated in the quantitative survey and have volunteered for follow-up interviews. At the end of the survey, participants were asked whether they are willing to take part in the qualitative phase, and if so, they would be asked to provide their contact information.

From seventeen volunteers, four teachers were selected using purposive sampling, ensuring diversity in terms of TPACK and innovativeness levels (e.g., high vs. low) and school type (public vs. private). These teachers participated in semi-structured interviews.

To facilitate accessibility and time management, interviews were conducted via Zoom with the participant's consent, and the sessions were video recorded. Each interview lasted approximately 20 to 30 minutes.

Voluntary participation was strictly prioritized, and all data from any participant who chooses to withdraw was permanently deleted to uphold ethical standards and participant autonomy.



4. DATA ANALYSIS

4.1. Descriptive Statistics

Descriptive statistics covered demographic data, including gender, age, type of school, and teaching experience. Statistics, containing means, standard deviations, and percentages, were employed to characterize the sample population.

4.2. Inferential Statistics

Inferential statistical tests were carried out to analyze the differences in TPACK and Individual Innovativeness scores among categorical groups. An independent sample t-test was used to examine group differences in technological pedagogical content knowledge (TPACK) and innovativeness (II) scores based on gender. Also a one-way ANOVA test was used to compare the mean scores of TPACK and individual innovativeness across varying years of teaching experience. Post Hoc test was applied to find out which group or groups' TPACK and individual innovativeness were significantly different according to their teaching experience..

The Pearson R test was used to examine the relationship between mathematics teachers' TPACK and individual innovation (II) scores. The normality assumption of the distribution was reported before applying the test.

4.2.1. Assumption Check for Correlation Analysis

The normality assumption for both variables was assessed prior to conducting the Pearson correlation analysis.

Evaluating normality is essential, as Pearson's correlation requires that the variables demonstrate an approximate normal distribution to ensure the validity and reliability of the statistical results (Field, 2018).

Table 4.1. Test of normality: TPACK.

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TPACK	,056	130	,200*	,992	130	,660

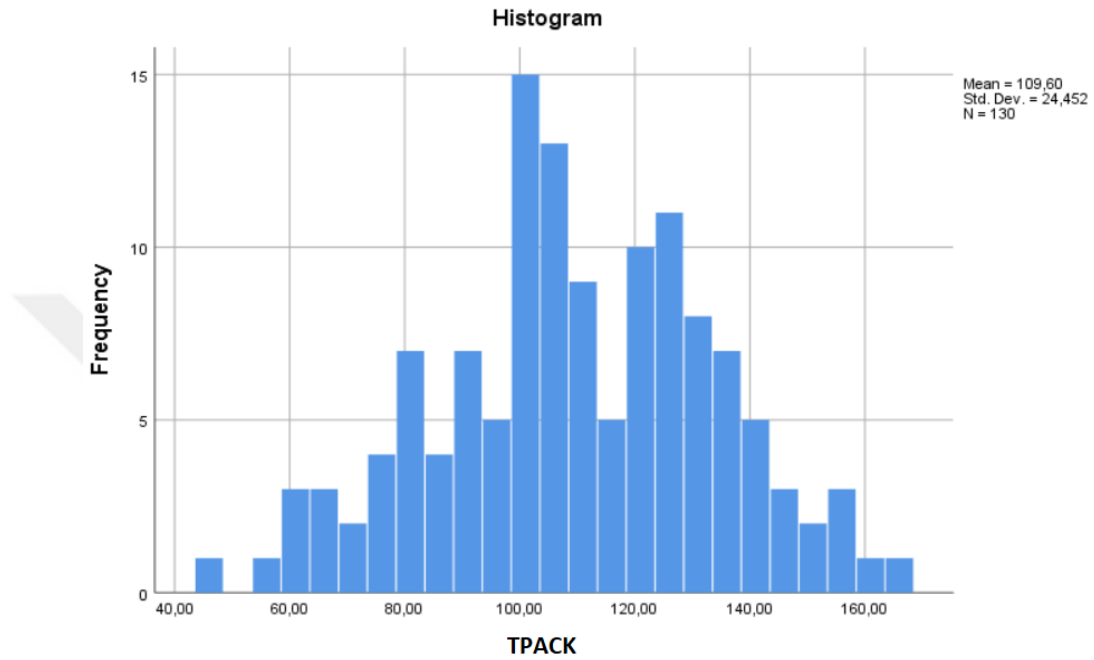


Figure 4.1. Histogram: TPACK.

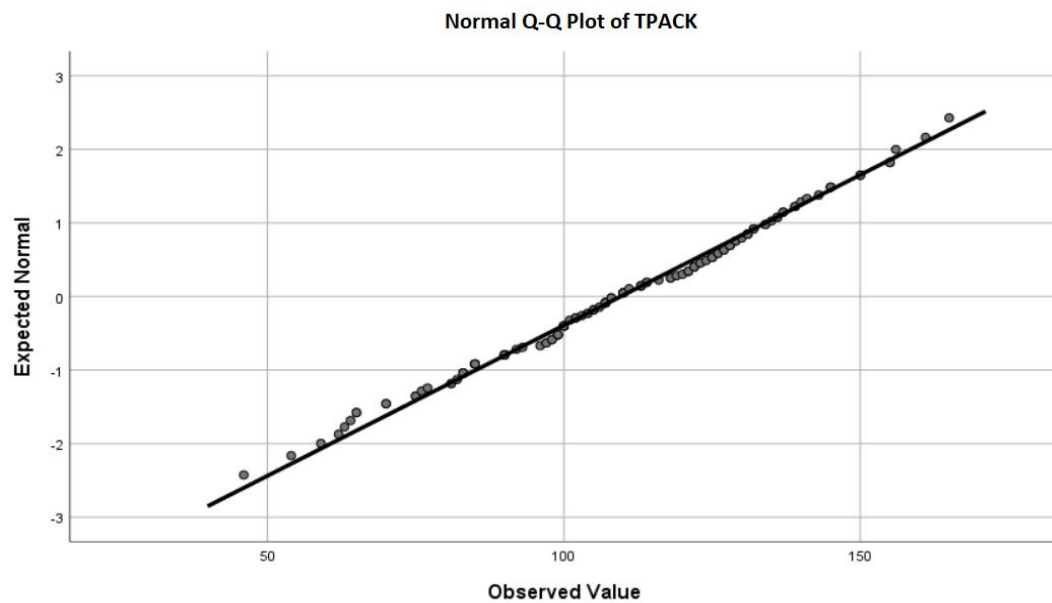


Figure 4.2. Q-Q Plot: TPACK.

Shapiro–Wilk test is used to check normality. Also the histogram and Q–Q plot are used to see if the TPACK scores were normal. The results showed that the TPACK scores were not significantly different from a normal distribution: $S-W(130) = .992$, $p = .660$.

The histogram in Figure 4.1 showed a bell-shaped curve. Also the Q–Q plot in Figure 4.2 showed that the values were very close to the diagonal line. So these figures also supported the normality of TPACK.

Table 4.2. Test of normality: Innovativeness.

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Innovativeness	,067	130	,200*	,986	130	,188

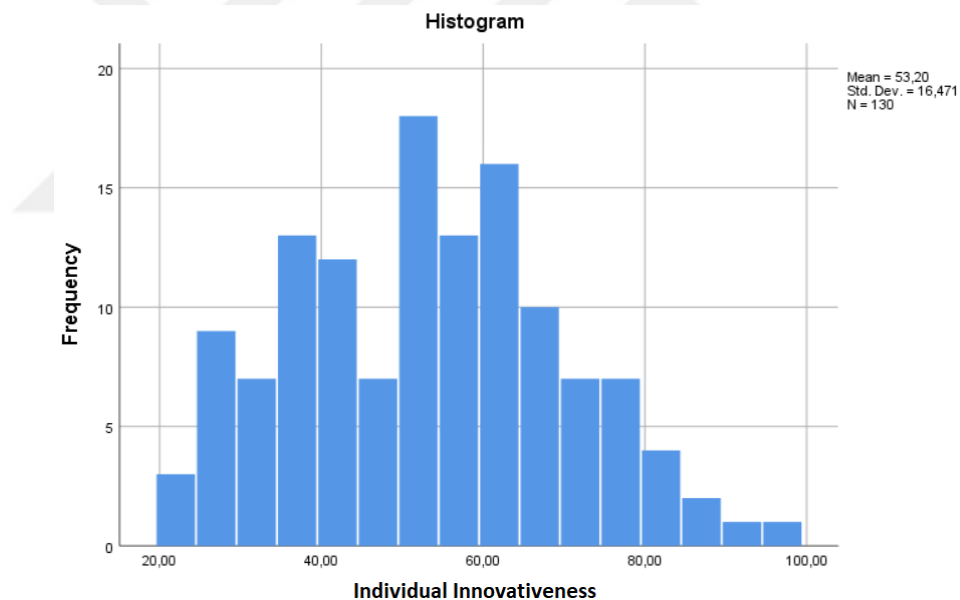


Figure 4.3. Histogram: Individual innovativeness.

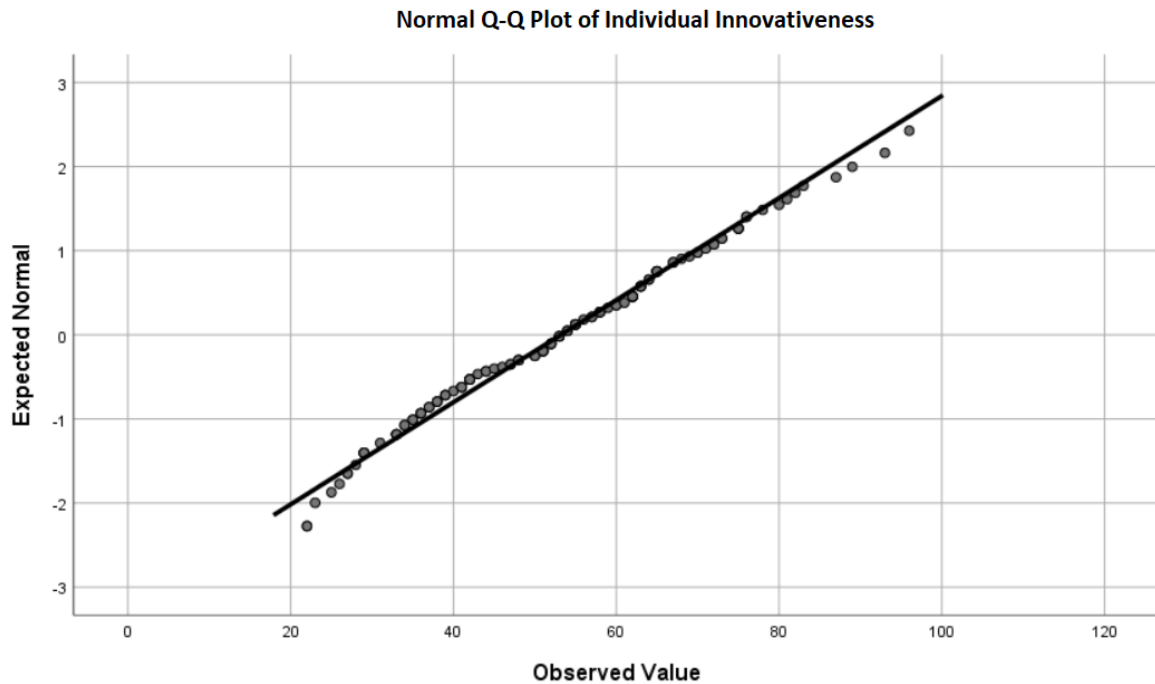


Figure 4.4. Q-Q Plot: Individual innovativeness.

The Shapiro-Wilk test is used to check the normality. The test results showed that the score distribution was not significantly different from normality. $S-W(130) = .986$, $p = .188$.

The histogram in Figure 4.3 showed a distribution that has a similarly symmetrical shape. Also the Q-Q plot in Figure 4.4 showed that the values were close to the diagonal line. The visual clues backed up the statistical result. So the assumption of normality for individual innovativeness scores is met.

4.2.2. Assumption Checks for t-Test: TPACK by Gender

The results of the normality assumption tests for female teachers' TPACK scores are presented below.

Table 4.3. Normality assumption for female teachers' TPACK scores.

TPACK	Gender	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TPACK	Female	,092	67	,200*	,978	67	,295

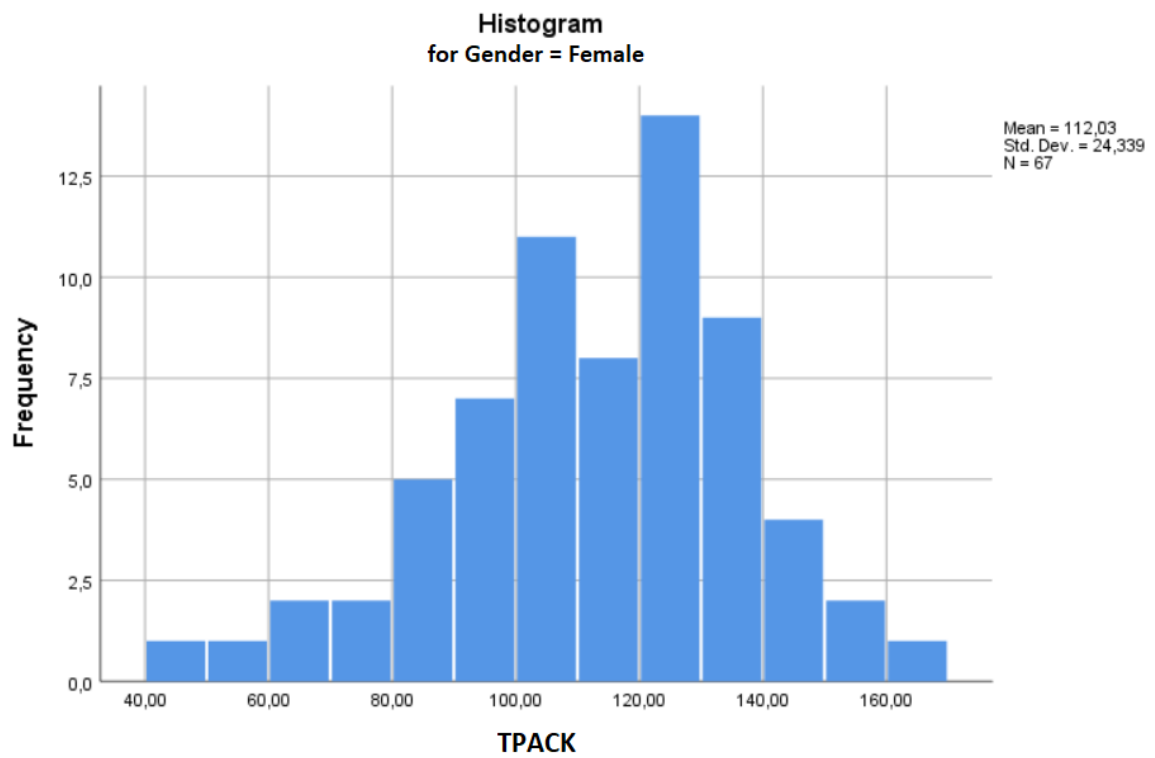


Figure 4.5. Histogram of TPACK scores (Female participants).

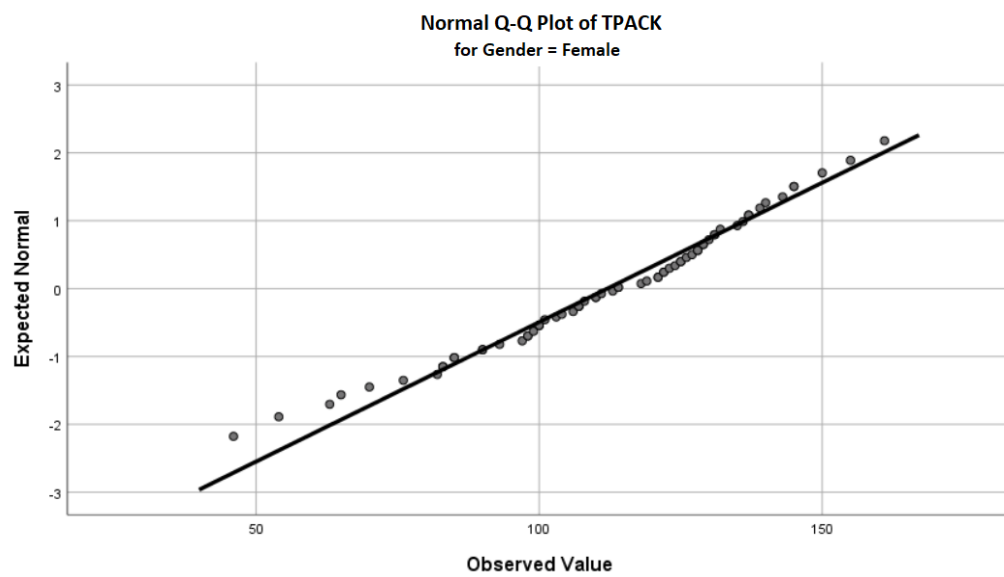


Figure 4.6. Q-Q Plot of TPACK scores (Female participants).

The Kolmogorov-Smirnov and Shapiro-Wilk tests were employed to assess the normality of TPACK scores in female educators. The results demonstrated no significant deviation from normal distribution (Kolmogorov-Smirnov: $D(67) = 0.092$, $p = .200$; Shapiro-Wilk: $W(67) = 0.978$, $p = .295$), indicating that the distribution of TPACK scores among female participants is approximately normal.

Figure 4.5 illustrates a histogram that displays a relatively symmetric distribution centered around the mean ($M = 112.03$, $SD = 24.34$), thus providing visual support for the normality assumption. The Q-Q plot (Figure 4.6) demonstrates that the data points align closely with the diagonal line, supporting the conclusion that the TPACK scores of female teachers follow a normal distribution.

Independence

The study design upheld the assumption of independence of observations, as each participant completed the survey independently.

Table 4.4. Normality assumption for male teachers' TPACK scores.

TPACK	Gender	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
	Male	,071	63	,200*	,988	63	,780

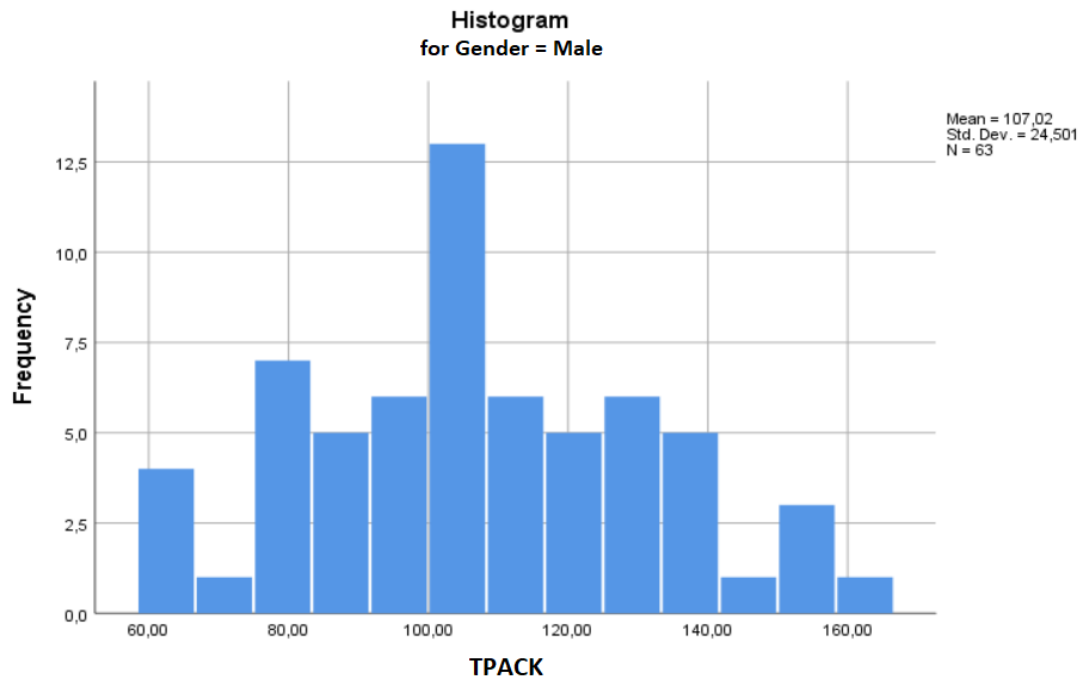


Figure 4.7. Histogram of TPACK scores (Male participants).

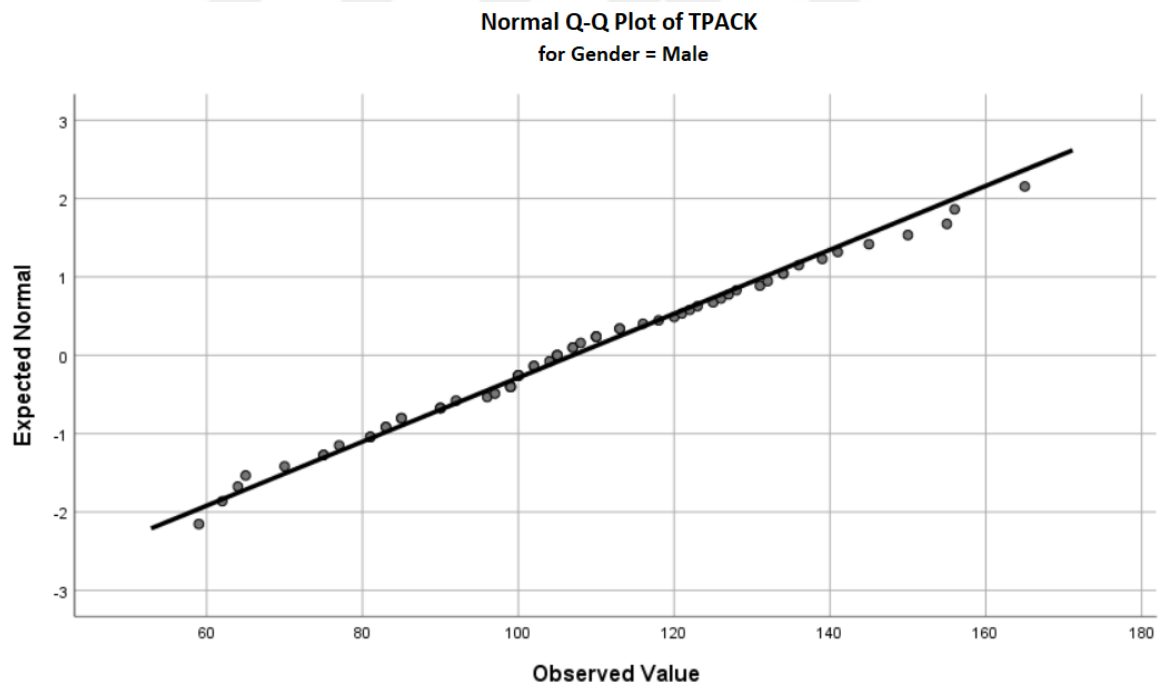


Figure 4.8. Q-Q Plot of TPACK scores (Male participants).

The Kolmogorov-Smirnov and Shapiro-Wilk tests were performed to assess the normality assumption for the TPACK scores of male teachers. The findings demonstrated that the data did not significantly differ from a normal distribution in both tests

(Kolmogorov-Smirnov: $D(63) = 0.071$, $p = .200$; Shapiro-Wilk: $W(63) = 0.988$, $p = .780$). The results indicate that the distribution of TPACK scores among male teachers approximates a normal distribution.

The histogram presented in Figure 4.7 corroborates the assumption of normality, exhibiting a nearly symmetric distribution centered at the mean ($M = 107.02$, $SD = 24.50$). The Q-Q plot (Figure 4.8) demonstrates that the data points closely align with the diagonal line, indicating that the TPACK scores of male participants exhibit a normal distribution.

Independence

The study design ensured the independence of observations, as each participant completed the survey independently.

4.2.3. Assumption Checks for t-Test: Individual Innovativeness by Gender

Prior to t-test to investigate the Individual Innovativeness differences by gender; assumptions which are scale of measurement, normality, homogeneity of variances and independence are checked. The scale of measurement is continuous for both TPACK and Individual Innovativeness Survey. Other following assumptions were examined below.

Table 4.5. Normality assumption for female teachers' individual innovativeness scores.

Individual Innovativeness	Gender	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
	Female	,08	67	,200*	,98	67	,56

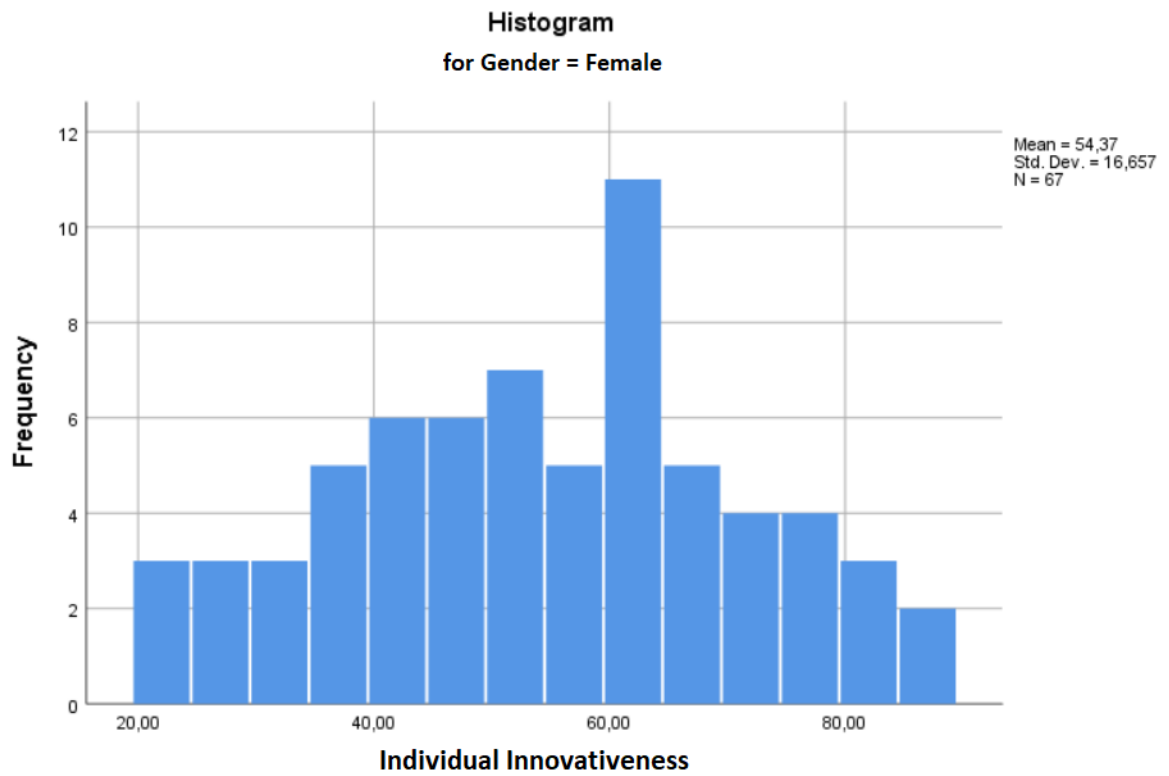


Figure 4.9. Histogram of individual innovativeness scores (Female participants).

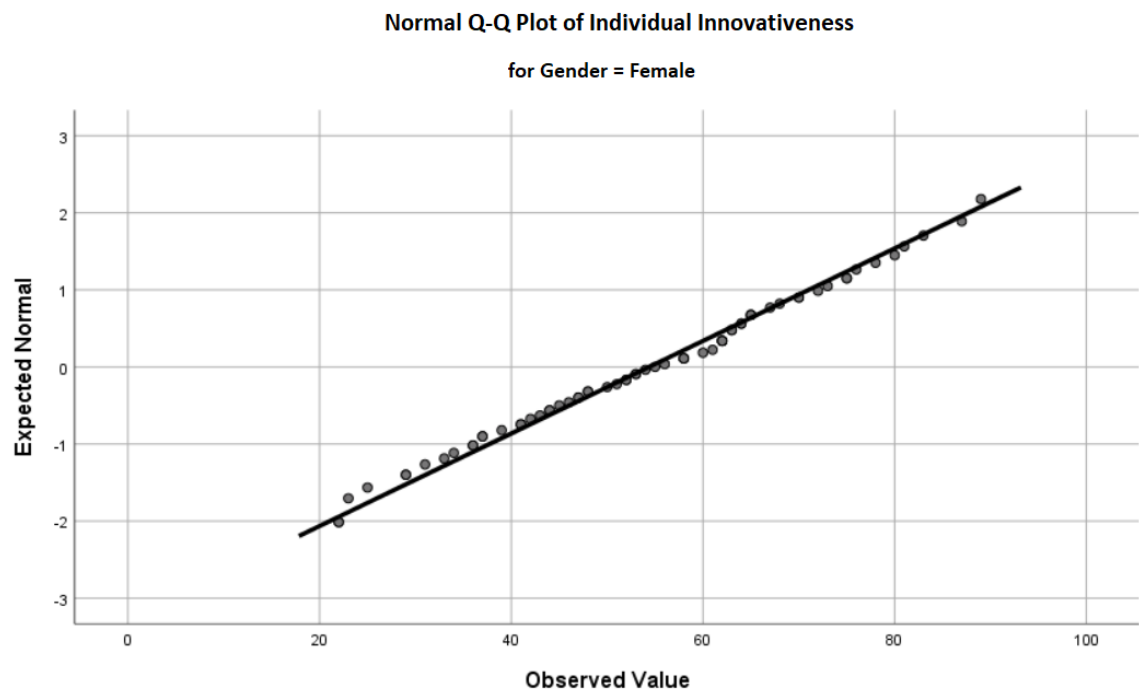


Figure 4.10. Q-Q Plot of TPACK scores (Female participants).

The Kolmogorov-Smirnov and Shapiro-Wilk tests were utilized to evaluate the normality of individual innovativeness scores among female teachers. The findings indicated no significant deviation from normal distribution (Kolmogorov-Smirnov: $D(67) = 0.080$, $p = .200$; Shapiro-Wilk: $W(67) = 0.980$, $p = .560$), suggesting that the distribution of individual innovativeness scores among female participants is approximately normal.

Figure 4.9 presents a histogram that demonstrates a symmetric distribution centered at the mean ($M = 54.37$, $SD = 16.66$), thereby supporting the normality assumption visually. The Q–Q plot (Figure 4.10) demonstrates that the data points closely align with the diagonal line, supporting the conclusion that the individual innovativeness scores of female teachers follow a normal distribution.

Table 4.6. Normality assumption for male teachers' individual innovativeness scores.

Individual Innovativeness	Gender Male	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
		,11	63	,06	,97	63	,08

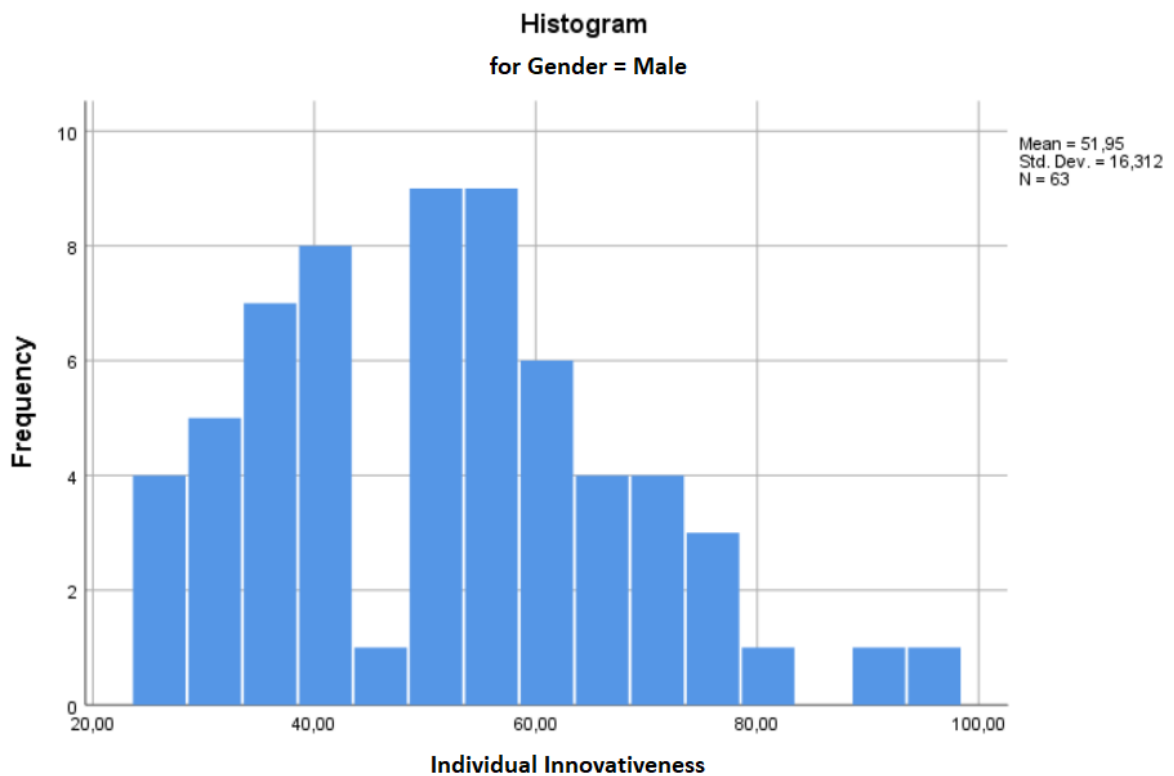


Figure 4.11. Histogram of individual innovativeness scores (Male participants).

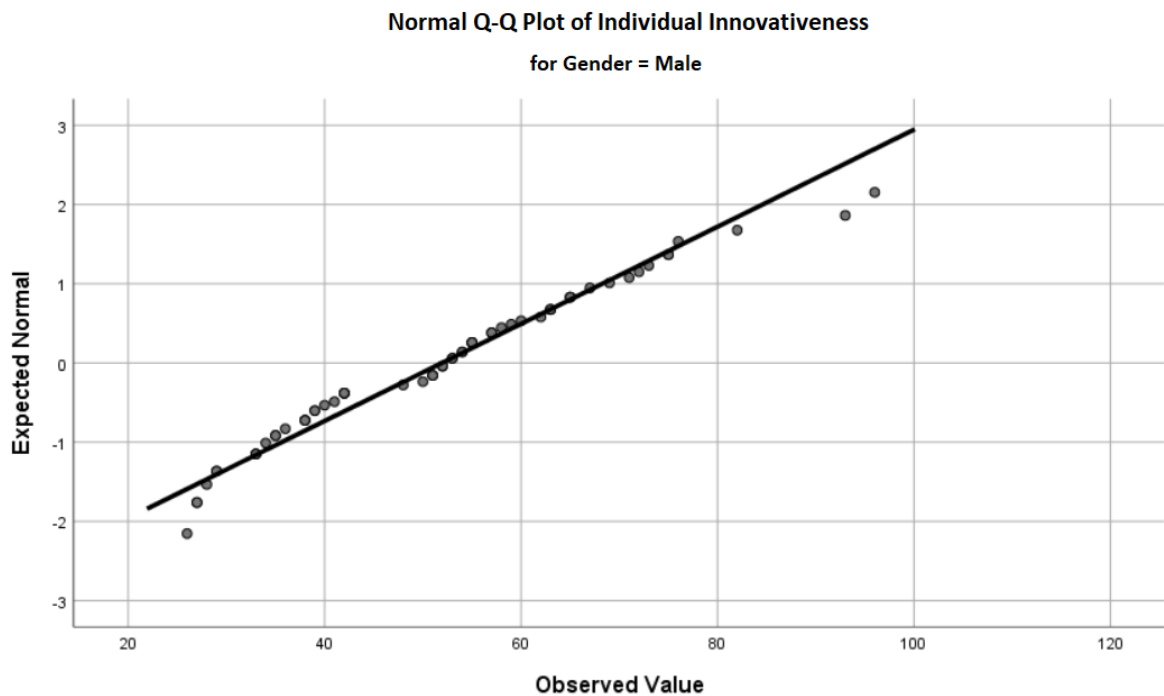


Figure 4.12. Q–Q Plot of individual innovativeness scores (Male participants).

Both the Kolmogorov-Smirnov and Shapiro-Wilk tests were employed to evaluate the normality of individual innovativeness scores among male teachers. The findings demonstrated no significant departure from normality (Kolmogorov-Smirnov: $D(63) = .11$, $p = .06$; Shapiro-Wilk: $W(63) = .97$, $p = .08$), indicating that the distribution of individual innovativeness scores may be regarded as approximately normal.

The histogram in Figure 4.11 supports these findings, displaying a distribution that is moderately symmetric and centered around the mean ($M = 51.95$, $SD = 16.31$). The Q-Q plot in Figure 4.12 shows data points that largely conform to the diagonal line, providing visual confirmation that the assumption of normality holds for the individual innovativeness scores of male participants.

Independence

The study design provided the independence of observations, with each participant completing the survey independently.

4.2.4. Assumption Check for ANOVA: TPACK by Years of Experience

In order to check the normality assumption required for the ANOVA analysis, the distribution of TPACK scores for teachers with 0–10 years of teaching experience was assessed. The results of the Kolmogorov-Smirnov and Shapiro-Wilk tests are summarized in Table 4.7.

Table 4.7. Normality checkfor TPACK scores: 0–10 years of teaching experience.

TPACK	Experience Years	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TPACK	0-10	,07	45	,200*	,98	45	,61

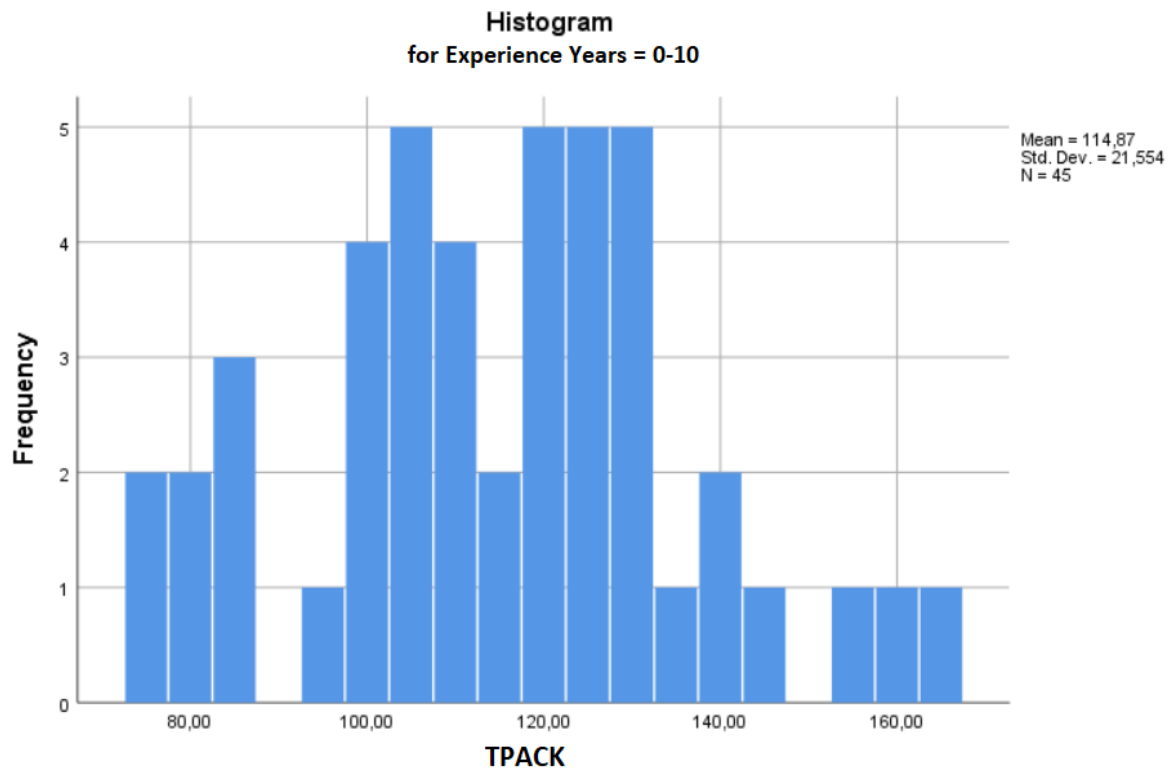


Figure 4.13. Histogram of TPACK scores (Experience years = 0-10).

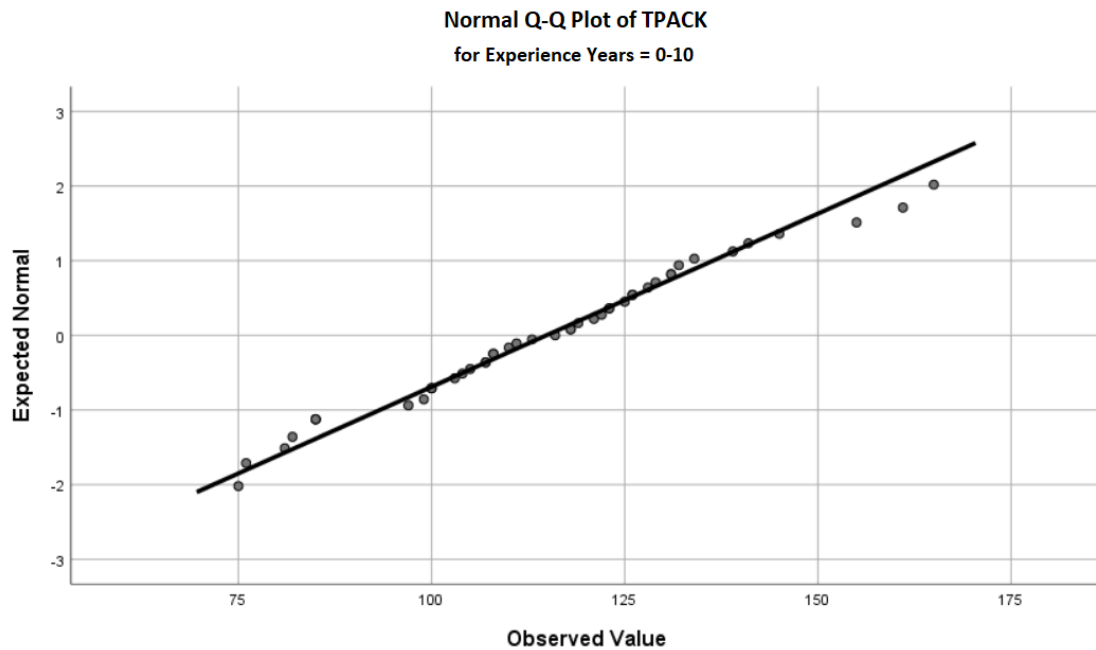


Figure 4.14. Q–Q Plot of TPACK scores (Experience years = 0-10).

The Kolmogorov–Smirnov and Shapiro–Wilk tests were conducted to evaluate the normality assumption for teachers with 0 to 10 years of experience. The findings demonstrated no significant deviation from normality (Kolmogorov–Smirnov: $D(45) = .073$, $p = .200$; Shapiro–Wilk: $W(45) = .980$, $p = .610$). The results suggest that the distribution of TPACK scores among teachers in this sample approximates a normal distribution.

The histogram (Figure 4.13) indicates a symmetric distribution centered at the mean ($M = 114.87$, $SD = 21.55$), thereby supporting the normality assumption. The Q–Q plot (Figure 4.14) demonstrates that the data points closely align with the diagonal line, further confirming the normal distribution of the data.

Table 4.8. Normality checkfor TPACK scores: 11–20 years of teaching experience.

TPACK	Experience Years	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TPACK	10-20	,09	44	,200*	,98	44	,48

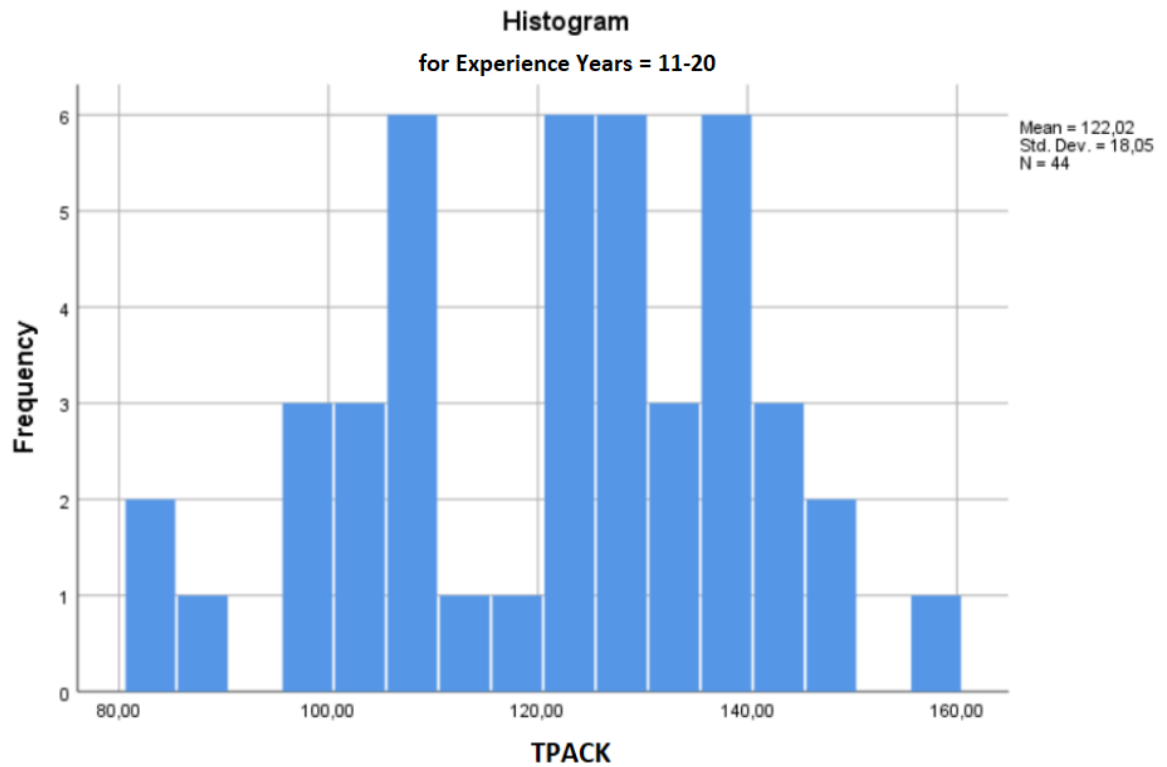


Figure 4.15. Histogram of TPACK scores (Experience years = 11-20).

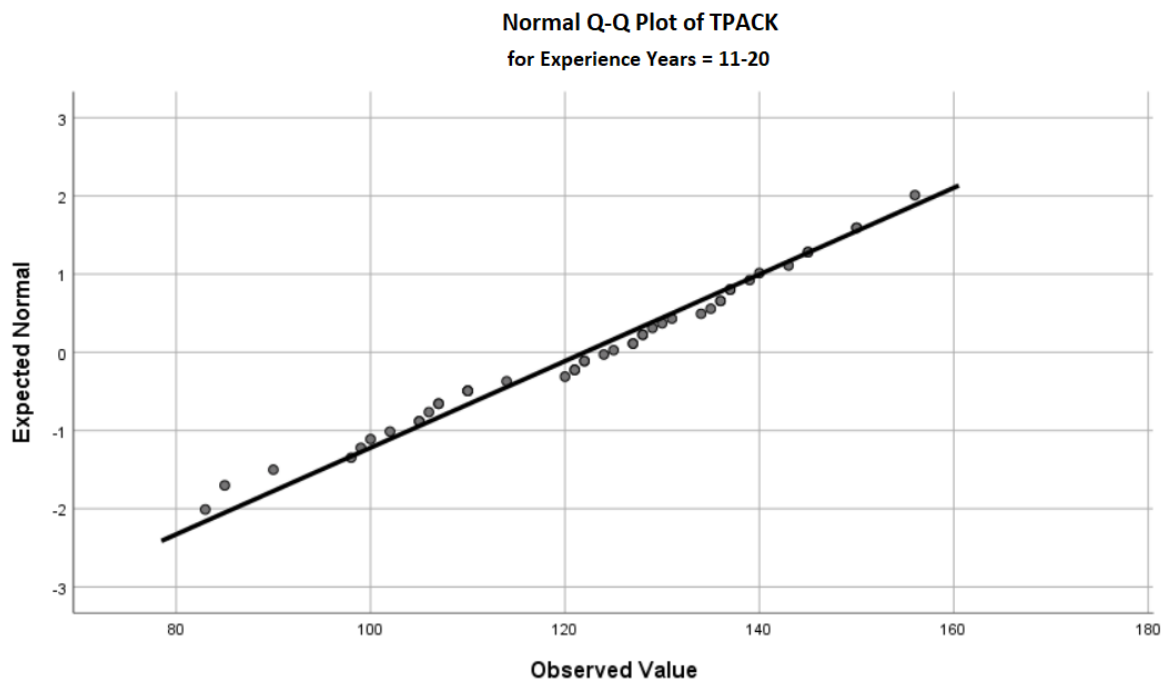


Figure 4.16. Q-Q Plot of TPACK scores (Experience years = 11-20).

The normality of TPACK scores for teachers with 11–20 years of experience was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. The findings showed no

significant deviation from normality (Kolmogorov-Smirnov: $D(44) = 0.090$, $p = .200$; Shapiro-Wilk: $W(44) = 0.98$, $p = .48$). The findings suggest that the TPACK score distribution for this experience group approximates a normal distribution.

Figure 4.15 presents the histogram of TPACK scores, demonstrating a symmetrical distribution centered around the mean ($M = 122.02$, $SD = 18.05$). Figure 4.16 presents a Q-Q plot indicating that the data points closely follow the diagonal line, thus supporting the assumption of normality for this group.

Table 4.9. Normality checkfor TPACK scores: 20+ years of teaching experience.

TPACK	Experience Years	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
TPACK	20+	,10	41	,200*	,97	41	,44

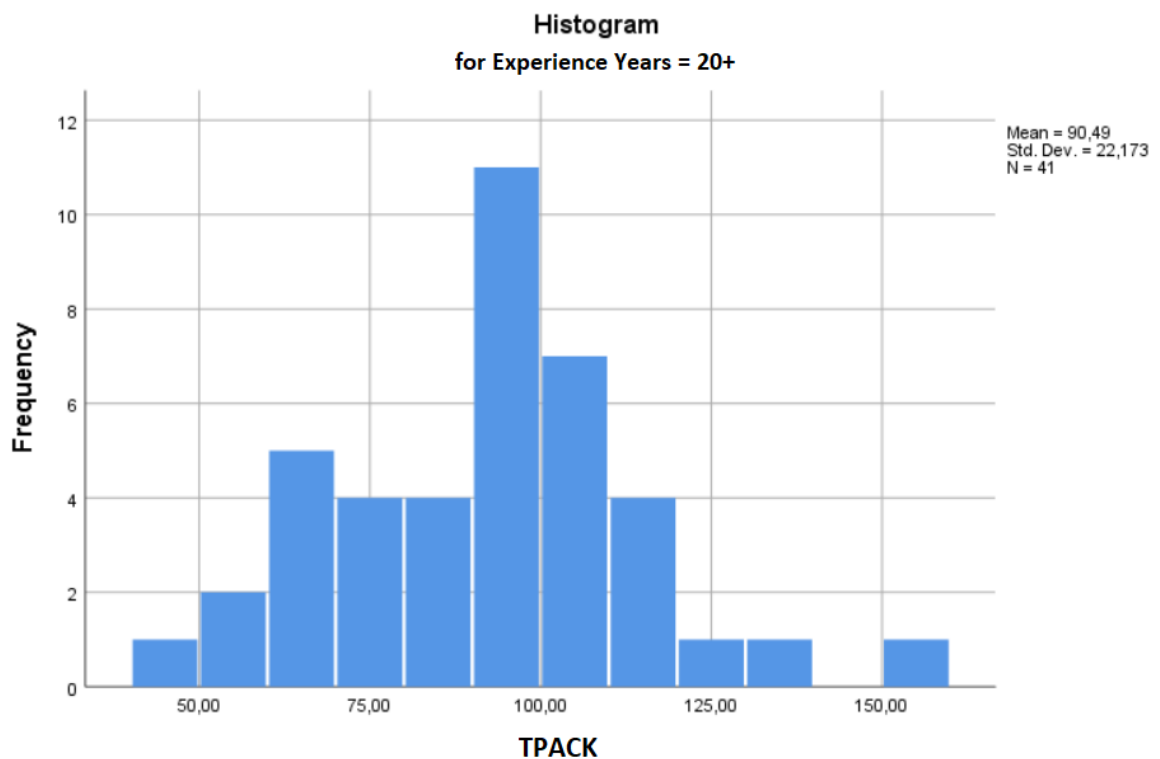


Figure 4.17. Histogram of TPACK scores (Experience years = 20+).

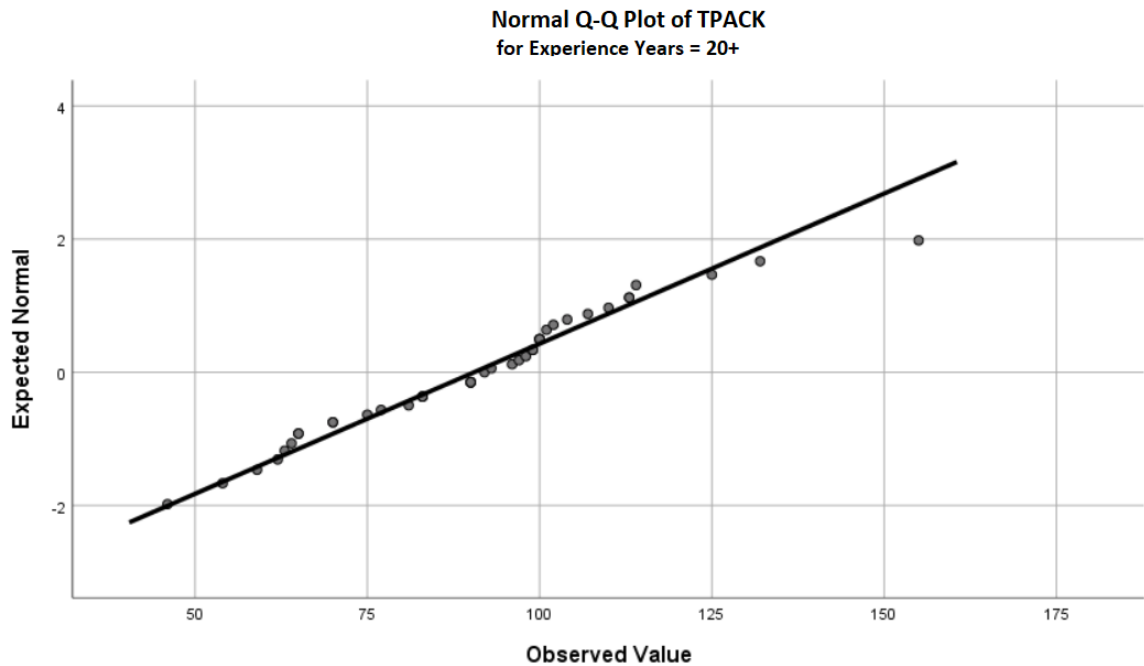


Figure 4.18. Q–Q Plot of TPACK scores (Experience years = 20+).

The Kolmogorov–Smirnov and Shapiro–Wilk tests were performed to determine the normal distribution of TPACK scores in participants with more than 20 years of teaching experience. Both tests indicated no significant deviation from normality (Kolmogorov–Smirnov: $D(41) = 0.10$, $p = .200$; Shapiro–Wilk: $W(41) = 0.97$, $p = .44$), suggesting that the distribution of TPACK scores in this group closely approximates a normal distribution.

The histogram (Figure 4.17) supports this finding, displaying a unimodal and symmetric distribution centered at the mean ($M = 90.49$, $SD = 22.17$). The Q–Q plot (Figure 4.18) demonstrates that the observed values align closely with the expected diagonal line, thereby supporting the normality of the TPACK scores for teachers with over 20 years of experience.

Table 4.10. Test of homogeneity of variances.

		Levene Statistic	df1	df2	Sig.
TPACK	Based on Mean	,52	2	127	,60
	Based on Median	,53	2	127	,59
	Based on Median and with adjusted df	,53	2	120,87	,59
	Based on trimmed mean	,54	2	127	,59

Levene's test was conducted to assess the validity of the homogeneity of variances assumption for TPACK scores across different teaching experience groups. The results indicated that the variance in TPACK scores was not significantly different across the groups, $F(2, 127) = 0.52, p = .60$. The assumption of homogeneity of variances was satisfied, allowing for the application of one-way ANOVA under the condition of equal variances.

Independence Assumption in One-Way ANOVA

The independence of observations was evaluated based on the study design. The independence assumption was met, as TPACK scores were collected from individual teachers who responded independently, with each participant assigned to a single teaching experience group.

4.2.5. Assumption Checks for ANOVA: Individual Innovativeness by Years of Experience

The normality of individual innovativeness scores for teachers with 0–10 years of experience was examined using both statistical tests and graphical methods. The results of the Kolmogorov-Smirnov and Shapiro-Wilk tests, along with the corresponding histogram and Q–Q plot, are presented below.

Table 4.11. Normality check for individual innovativeness scores: 0–10 years of teaching experience.

Individual Innovativeness	Experience Years	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
	0-10	,07	45	,200*	,99	45	,81

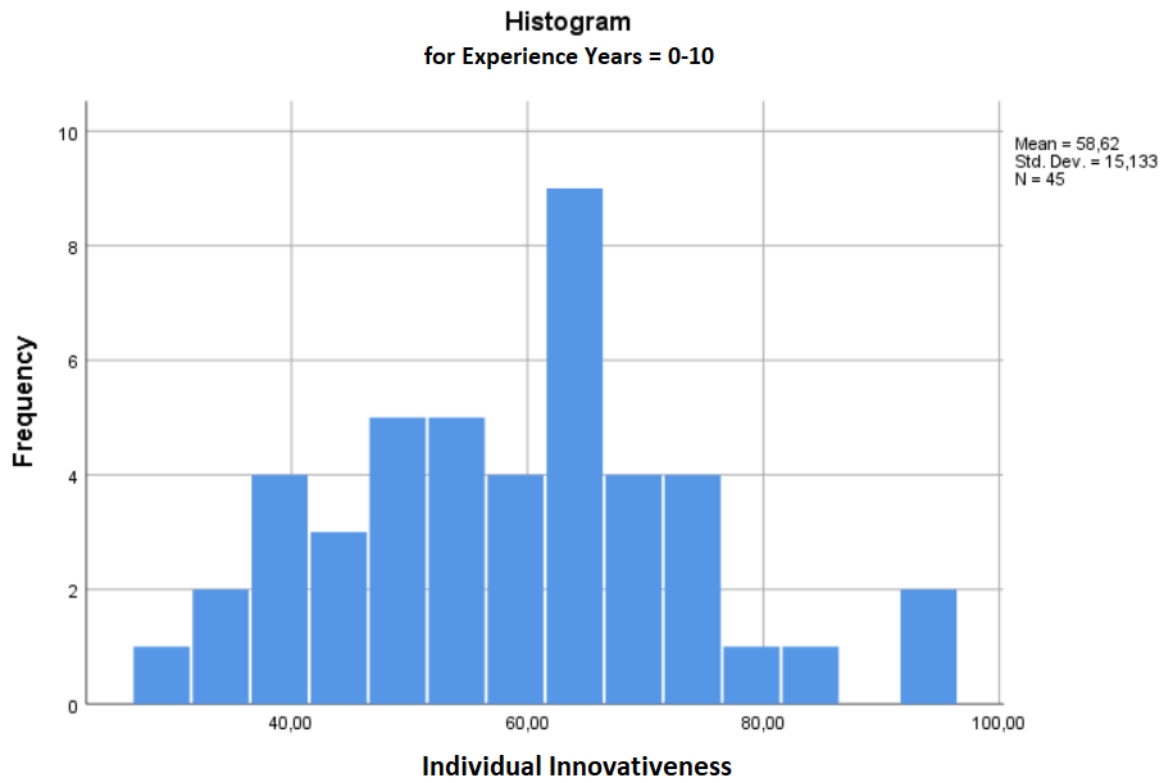


Figure 4.19. Histogram of individual innovativeness scores (Experience years = 0-10).

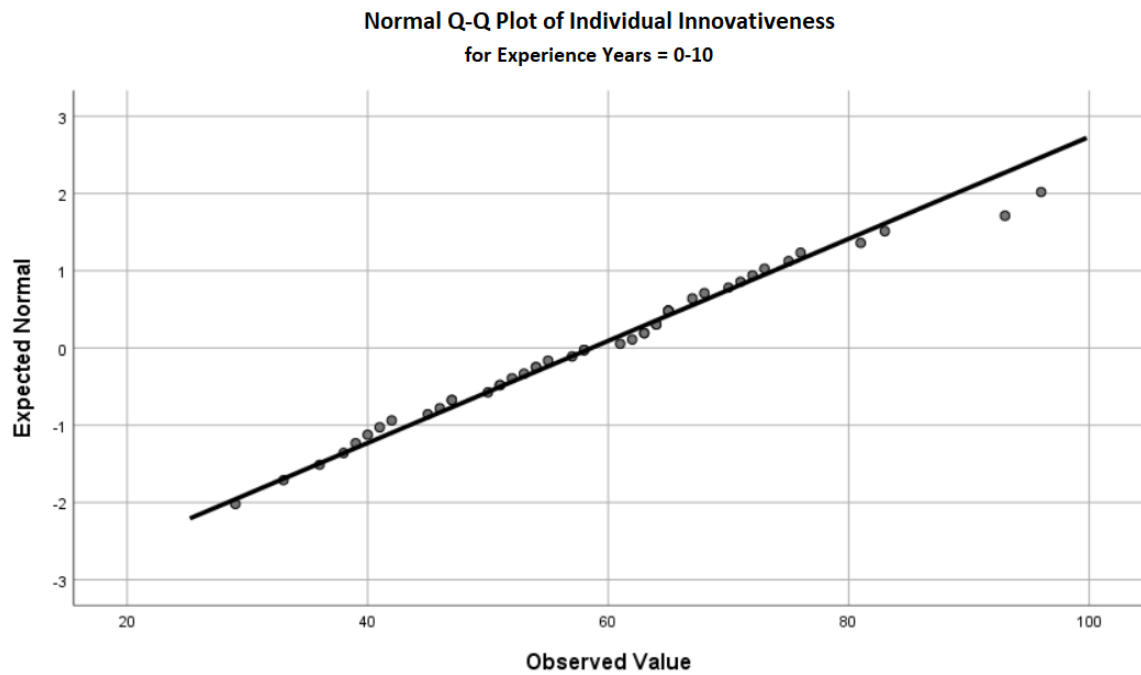


Figure 4.20. Q-Q Plot of TPACK scores (Experience years = 0-10).

Kolmogorov-Smirnov and Shapiro-Wilk tests were conducted to evaluate whether the distribution of individual innovativeness scores for teachers with 0–10 years of experience met the normality assumption. The results indicated no significant deviation from a normal distribution (Kolmogorov-Smirnov: $D(45) = 0.07$, $p = .200$; Shapiro-Wilk: $W(45) = 0.99$, $p = .81$), confirming that the normality assumption was upheld.

Visual assessments supported this conclusion. The histogram (Figure 4.19) demonstrates that the distribution of individual innovativeness scores is nearly symmetric and centered at the mean ($M = 58.62$, $SD = 15.13$). The Q-Q plot (Figure 4.20) displayed data points that closely followed the reference line, thereby supporting the assumption of normality.

Table 4.12. Normality check for individual innovativeness scores: 11-20 years of teaching experience

Individual Innovativeness	Experience Years	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
	11-20	,12	44	,09	,96	44	,16

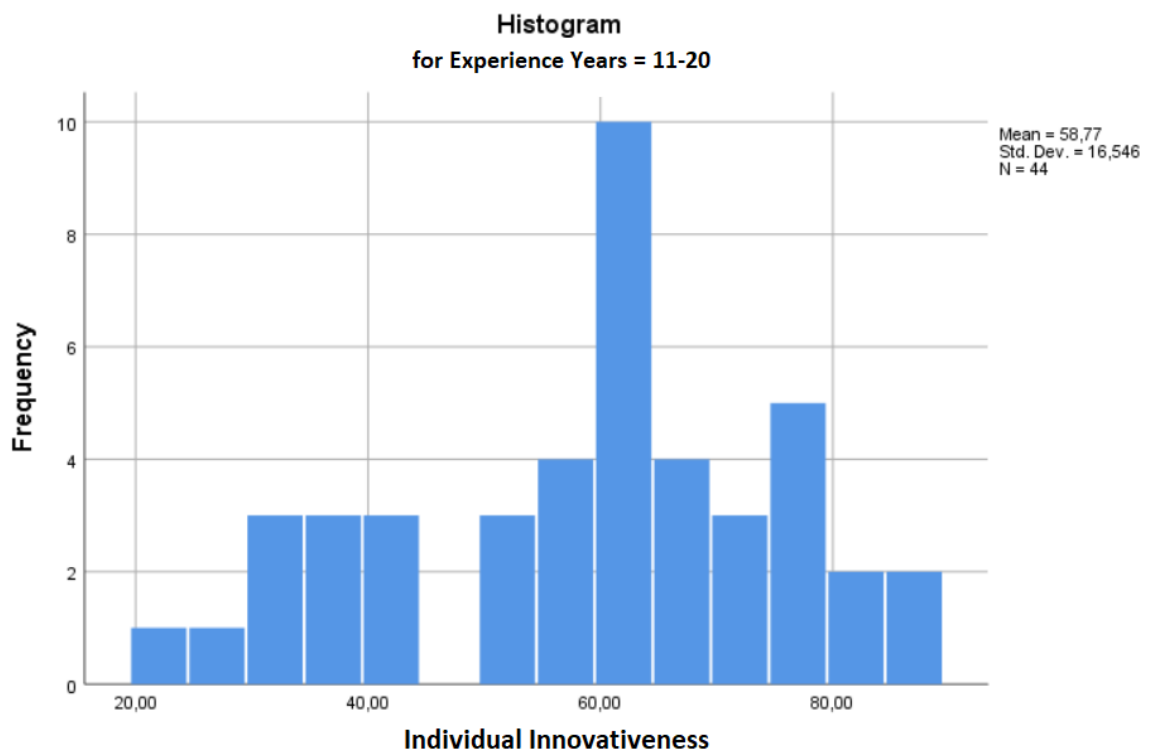


Figure 4.21. Histogram of individual innovativeness scores (Experience years = 11-20).

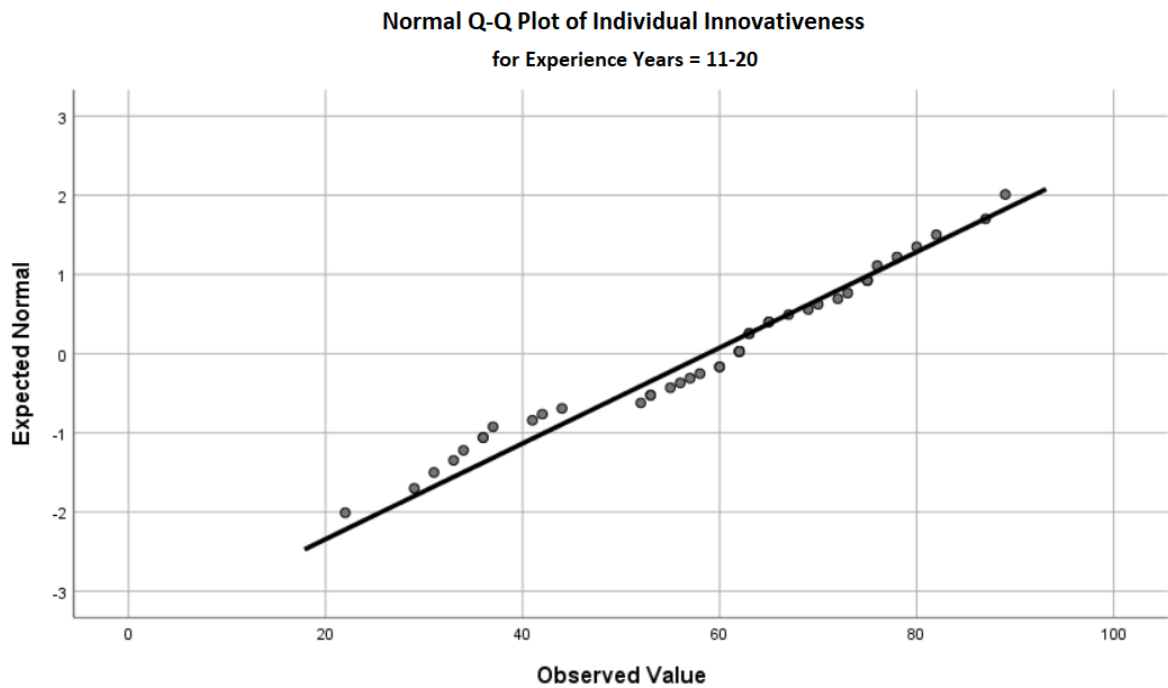


Figure 4.22. Q–Q Plot of TPACK scores (Experience years = 11-20).

The Kolmogorov–Smirnov and Shapiro–Wilk tests were conducted to examine the normal distribution of individual innovativeness scores among teachers with 11–20 years of experience. The results showed no significant departure from normality (Kolmogorov–Smirnov: $D(44) = 0.12$, $p = .09$; Shapiro–Wilk: $W(44) = 0.96$, $p = .16$), indicating that the data can be considered approximately normally distributed.

The histogram (Figure 4.21) displayed a bell-shaped distribution centered at the mean ($M = 58.77$, $SD = 16.55$), and the Q–Q plot (Figure 4.22) showed that most data points closely followed the expected diagonal line. The results provide visual confirmation that corroborates the statistical evaluations of normality.

Table 4.13. Normality check for individual innovativeness scores: 20+ years of teaching experience.

Individual Innovativeness	Experience Years 20+	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
		,13	41	,11	,95	41	,08

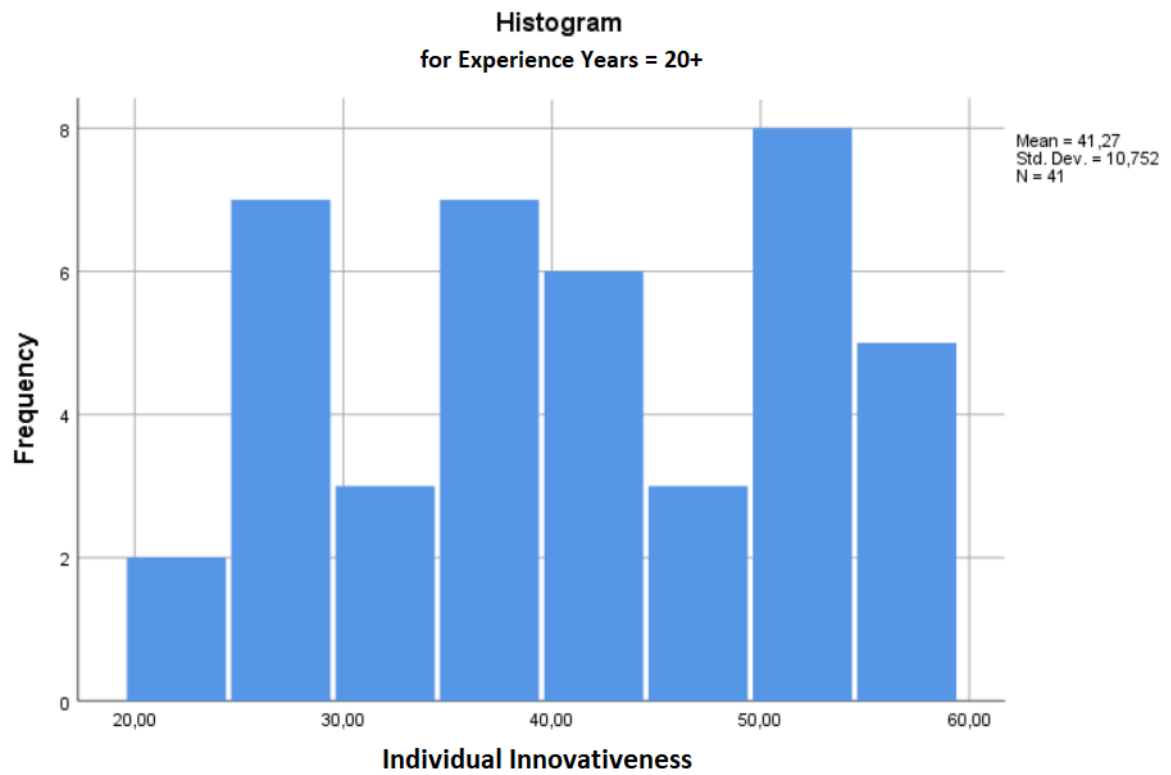


Figure 4.23. Histogram of individual innovativeness scores (Experience years = 20+).

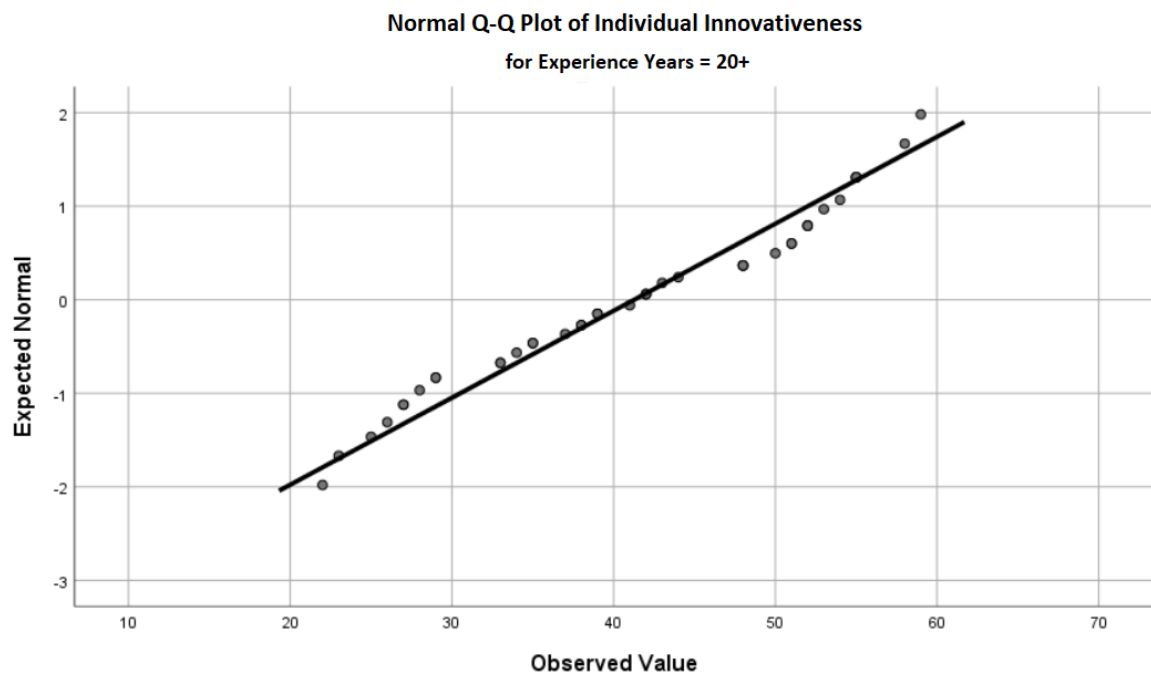


Figure 4.24. Q-Q Plot of TPACK scores (Experience years = 20+).

The Kolmogorov-Smirnov and Shapiro-Wilk tests were conducted to evaluate the normality assumption for the individual innovativeness scores of teachers possessing over 20 years of teaching experience. The results indicated that the data did not significantly deviate from a normal distribution (Kolmogorov-Smirnov: $D(41) = 0.13$, $p = .11$; Shapiro-Wilk: $W(41) = 0.95$, $p = .08$), confirming that the normality assumption holds.

The visual inspection confirmed this conclusion. The histogram (Figure 4.23) demonstrates that the distribution is roughly symmetric. The Q-Q plot (Figure 4.24) shows that the data points largely conform to the diagonal line, indicating that the distribution of individual innovativeness scores for the group with over 20 years of experience is approximately normal.

Table 4.14. Test of homogeneity of variances.

		Levene Statistic	df1	df2	Sig.
Individual Innovativeness	Based on Mean	2,59	2	127	,08
	Based on Median	2,00	2	127	,14
	Based on Median and with adjusted df	2,00	2	105,01	,14
	Based on trimmed mean	2,53	2	127	,08

Levene's test was conducted to assess the validity of the homogeneity of variances assumption for individual innovativeness scores across different teaching experience groups. The results indicated that the variance in individual innovativeness scores was not significantly different across the groups, $F(2, 127) = 2.59$, $p = .08$. The assumption of homogeneity of variances was satisfied, allowing for the application of one-way ANOVA under the condition of equal variances.

Assumption of Independence in One-Way ANOVA

The independence of observations was evaluated based on the study design. The independence assumption was met, as TPACK scores were collected from individual teachers who responded independently, with each participant assigned to a single teaching experience group. The assumption is ensured by the between-subjects design of the study and the lack of repeated measures or nested data structures. The dataset meets the independence criterion necessary for conducting a one-way ANOVA.

4.3. Qualitative Analysis

Didactic thematic analysis was used in the qualitative study. Five predetermined themes were identified: technology budget, technology ownership, update frequency for technological devices, quantity of internet applications utilized, and internet usage patterns.

After conducting semi-structured interviews with the narrators, the responses were transcribed. Open coding was then applied, and the ATLAS.ti application was used for analysis. Codes were constructed based on transcripts, and similar codes were grouped.

The researcher and a second coder independently coded the transcripts. The identified areas were then compared. Cohen's Kappa coefficient measured coding reliability. In this study, based on the coding, a consensus of approximately 0.87 was provided between the two coders. The two coders discussed the differences and reached a consensus.

5. RESULTS

The quantitative part of the study investigated the correlation between Technological Pedagogical Content Knowledge (TPACK) of in-service middle school mathematics teachers and their levels of individual innovativeness. It also determines meaningful differences in different demographic groups which are gender and teaching experience years. Descriptive statistics summarize the participants' demographic information, such as their gender, years of teaching experience, and the school type teachers work. After collecting data through the survey, two main types of analysis were done. These are correlational and causal-comparative analysis. The correlational analysis determined whether there was a statistically significant correlation between teachers' TPACK and their individual innovativeness scores. Also, the causal-comparative analyses investigated the meaningful differences in TPACK and Individual Innovativeness (II) scores based on gender and teaching experience duration. Before carrying out inferential tests, statistical assumptions were checked. They are scale of measurement, normality, homogeneity of variances, and independence.

5.1. Participant Demographics

The descriptive statistics showed a mean score of 109.60 ($SD = 24.45$) for TPACK data and a mean score of 53.20 ($SD = 16.47$) for individual innovativeness data obtained from 130 mathematics teachers. The values demonstrated moderate variability in both TPACK and individual innovativeness among participants.

Table 5.1. Descriptive statistics for TPACK and individual innovativeness scores.

Variable	N	M	SD	Variance
Technological Pedagogical Content Knowledge (TPACK)	130	109.60	24.45	597.92
Individual Innovativeness (II)	130	53.20	16.47	271.31

Note. N = sample size; M = mean; SD = standard deviation.

5.2. Correlation between TPACK and Individual Innovativeness

5.2.1. Correlation Results

Pearson product-moment correlation was performed to examine the relationship between in-service middle school mathematics teachers' Technological Pedagogical Content Knowledge (TPACK) and their individual innovativeness levels. The normality assumption for TPACK and Individual Innovativeness was assessed prior to the analysis using the Shapiro–Wilk test.

The correlation analysis revealed a significant and positive strong correlation between TPACK and Individual Innovativeness scores, $r(128) = .630$, $p < .001$.

Table 5.2. Correlation between TPACK and individual innovativeness.

		TPACK	Individual Innovativeness
TPACK	Pearson Correlation	1	,630**
	Sig. (2-tailed)		,000
	N	130	130
Individual Innovativeness	Pearson Correlation	,630**	1
	Sig. (2-tailed)	,000	
	N	130	130

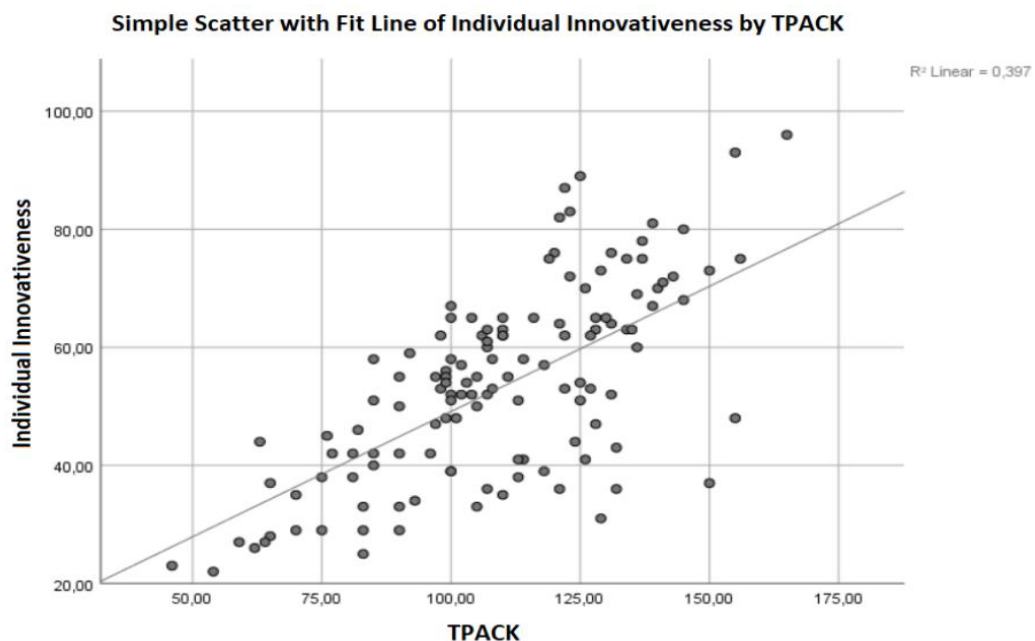


Figure 5.1. Scatter plot showing the positive linear relationship (N = 130).

This indicates that educators with higher individual innovativeness tend to report increased levels of TPACK.

The scatter plot (Figure 5.1) demonstrates that the data points cluster around the ascending regression line, signifying a positive linear correlation between the two variables. The coefficient of determination ($R^2 = .397$) suggests that approximately 39.7% of the variance in individual innovativeness can be explained by teachers' TPACK levels.

5.2.2. Analysis of TPACK Differences by Gender

Prior to t-test to investigate the TPACK differences by gender; assumptions which are scale of measurement, normality, homogeneity of variances and independence are checked. The scale of measurement is continuous for both TPACK and Individual Innovativeness Survey. Other following assumptions were examined in the data analysis part.

Table 5.3. Group statistics.

	Gender	N	Mean	Std. Deviation	Std. Error Mean
TPACK	Female	67	112,03	24,34	2,97
	Male	63	107,02	24,50	3,08

Table 5.4. Levene and t test: TPACK differences by gender.

		t-test for Equality of Means							95% Confidence Interval of the Difference	
Levene's Test for Equality of Variances		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
TPACK	Equal variances assumed	,002	,97	1,17	128	,24	5,01	4,29	-3,46	13,49
	Equal variances not assumed			1,11	117,03	,27	5,01	4,29	-3,47	13,49

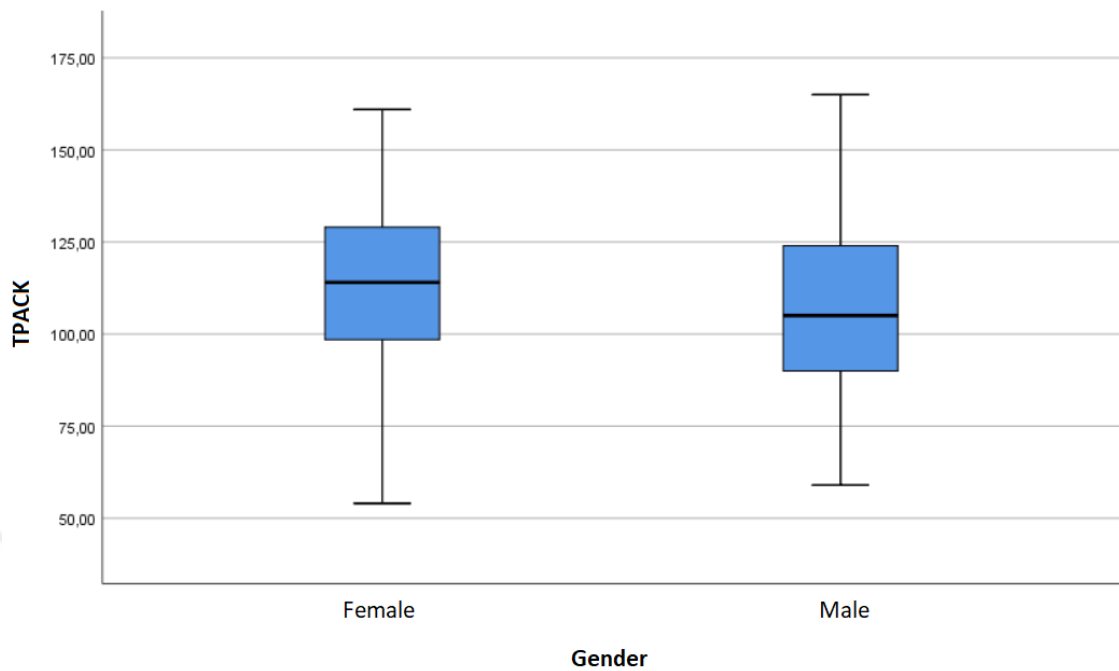


Figure 5.2. Boxplot of TPACK means.

The normality assumption was assessed through the Shapiro-Wilk and Kolmogorov-Smirnov tests. The findings demonstrated that the TPACK scores for female participants ($p = .295$) and male participants ($p = .780$) followed a normal distribution. Furthermore, visual examination of histograms and Q-Q plots confirmed the normal distribution of the data.

The assumption of homogeneity of variances was assessed through Levene's test. The findings indicated that the variance between the two groups was equal, $F(1, 128) = 0.002$, $p = .97$, thus confirming that this assumption was satisfied.

The study design ensured the assumption of independence, as the scores of one participant did not influence those of another.

An independent samples t-test indicated no statistically significant difference in TPACK scores between female ($M = 112.03$, $SD = 24.34$) and male ($M = 107.02$, $SD = 24.50$) teachers, $t(128) = 1.17$, $p = .24$, $d = 0.21$. The 95% confidence interval for the mean difference was between -3.46 and 13.49.

The results indicate that gender has no meaningful difference in TPACK scores based on gender.

5.2.3. Analysis of Individual Innovativeness Differences by Gender

Prior to conducting the independent samples t-test, the assumptions of continuity, normality, homogeneity of variances, and independence were evaluated. The assessment of normality was conducted using the Kolmogorov-Smirnov and Shapiro-Wilk tests, which provided supportive results for both female ($D(67) = .080$, $p = .200$; $W(67) = .980$, $p = .560$) and male ($D(63) = .110$, $p = .060$; $W(63) = .970$, $p = .080$) participants. The histograms and Q-Q plots offered visual confirmation of the normality assumption.

Levene's test indicated that the assumption of homogeneity of variances was met, $F(1, 128) = 0.196$, $p = .659$.

Table 5.5. Group statistics.

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Individual Innovativeness	Female	67	54,37	16,66	2,03
	Male	63	51,95	16,31	2,06

Table 5.6. t-test: individual innovativeness difference by gender

		t-test for Equality of Means							95% Confidence Interval of the Difference	
		Levene's Test for Equality of Variances	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	
Individual Innovativeness	Equal variances assumed		,20	,66	,84	128	,40	2,42	2,89	-3,31 8,15
	Equal variances not assumed				,84	127,78	,40	2,42	2,89	-3,30 8,14

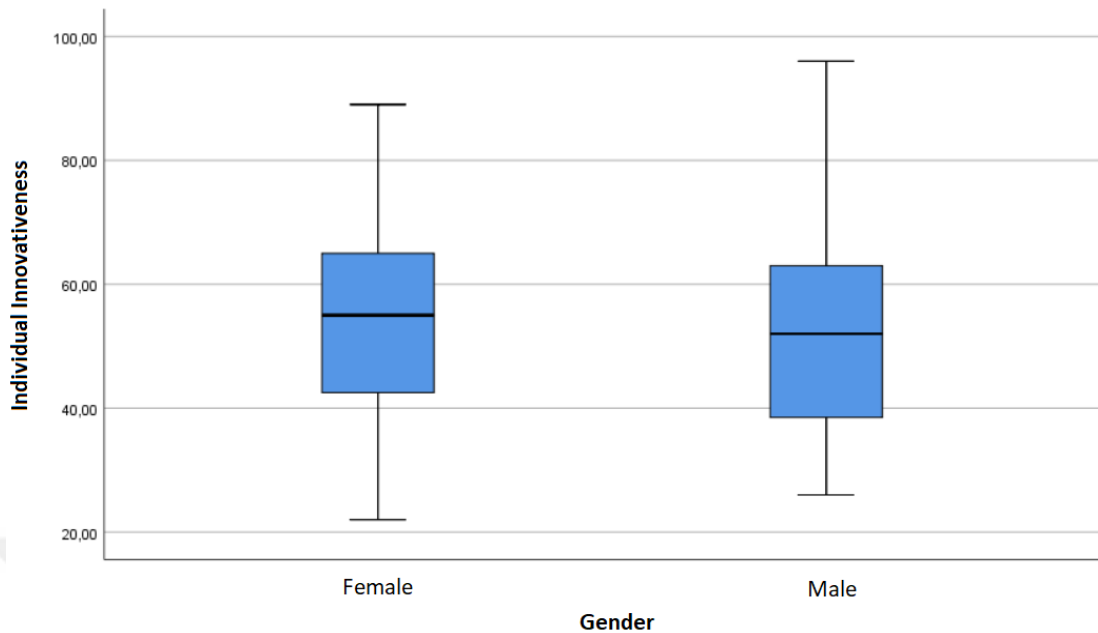


Figure 5.3. Boxplot of II means.

An independent samples t-test revealed that the difference in individual innovativeness scores between female ($M = 54.37$, $SD = 16.66$) and male teachers ($M = 51.95$, $SD = 16.31$) was not statistically significant, $t(128) = .836$, $p = .404$, 95% $CI [-3.31, 8.15]$. No meaningful difference in II scores based on gender was detected.

5.2.4. Analysis of TPACK Differences by Years of Experience

Prior to conducting ANOVA, the assumptions which are the scale of measurement, normality, homogeneity of variances and independence were checked.

5.2.4.1. ANOVA Results: TPACK Scores by Years of Experience. Table 5.7 presents the ANOVA results for TPACK scores across different years of teaching experience.

Table 5.7. ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	23014,78	2	11507,39	27,005	,000
Within Groups	54116,42	127	426,11		
Total	77131,20	129			

Table 5.8. Post hoc test multiple comparisons dependent variable: TPACKTukey HSD.

(I)Experience Years	(J)Experience Years	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
0-10	11-20	-7,16	4,38	,24	-17,53	3,22
	20+	24,38	4,46	,000	13,81	34,95
11-20	0-10	7,16	4,38	,24	-3,22	17,53
	20+	31,53	4,48	,000	20,91	42,16
20+	0-10	-24,38	4,46	,000	-34,95	-13,81
	11-20	-31,53	4,48	,000	-42,16	-20,91

The mean difference is significant at the 0.05 level.

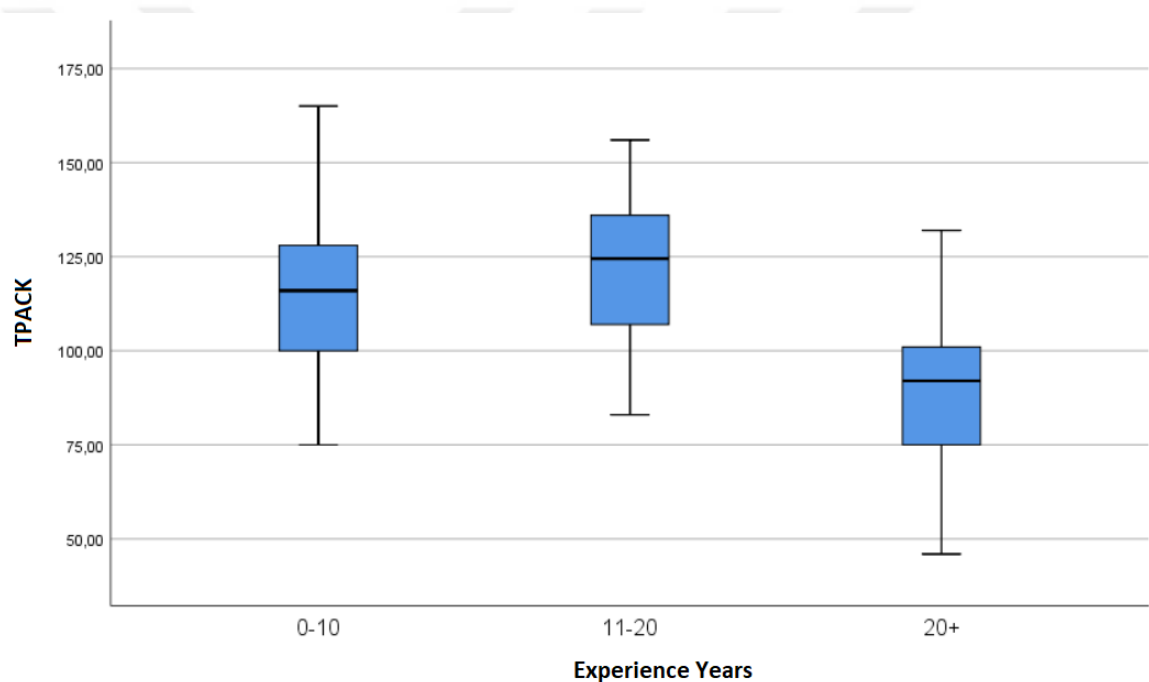


Figure 5.4. Boxplot of TPACK means.

A Tukey HSD post hoc test was conducted to determine the specific groups that showed differences in TPACK scores following the significant one-way ANOVA.

The findings revealed that educators with over 20 years of experience exhibited markedly lower TPACK scores than their counterparts with 0–10 years ($M = -24.38$, $SE = 4.46$, $p < .001$, 95% $CI [-34.95, -13.81]$) and those with 11–20 years of experience ($M = -31.53$, $SE = 4.48$, $p < .001$, 95% $CI [-42.16, -20.91]$).

No significant difference was observed between teachers with 0–10 years of experience and those with 11–20 years ($M = -7.16$, $SE = 4.38$, $p = .240$, 95% $CI[-17.53, 3.22]$).

The findings reveal a significant decrease in TPACK scores for teachers with more than 20 years of experience in contrast to their less experienced peers. The statistical analysis did not indicate a significant difference between teachers with 0–10 years of experience and those with 11–20 years of experience; however, the boxplot suggests a slight trend indicating that mid-career teachers exhibit higher levels of individual innovativeness. Although it is not statistically significant, the finding indicates that professional experience influences teachers' receptiveness to innovation and change.

Early-career teachers are often in the process of adjusting to institutional demands, classroom management, and curriculum expectations, which may limit their ability to experiment with new pedagogical tools (Day & Gu, 2007). Conversely, educators with 11–20 years of experience may attain a degree of professional stability that enables a greater emphasis on pedagogical innovation and the integration of technology. This group frequently employs accumulated teaching expertise while retaining the motivation and adaptability necessary to embrace innovative practices (Fullan, 2007; Rogers, 2003).

It is essential to interpret this finding cautiously, given that the observed difference lacked statistical significance. This indicates that elements beyond mere years of experience—such as institutional culture, availability of professional development, and personal attitudes towards change—could significantly influence innovativeness (Kılıçer&Odabaşı, 2010; Voogt et al., 2015). The trend offers valuable insights into the interaction between experience and teachers' innovative capacities, suggesting a potential avenue for future research.

5.2.5. Analysis of Individual Innovativeness Differences by Years of Experience

5.2.5.1. ANOVA Results: Individual Innovativeness by Years of Experience. A one-way between-groups analysis is conducted. An ANOVA was conducted to evaluate the effect of teaching experience on individual innovativeness scores. The results demonstrated a

statistically significant difference in individual innovativeness scores across the three teaching experience groups, $F(2, 127) = 20.45$, $p < .001$. This indicates that at least one group's mean score on individual innovativeness significantly differed from the others.

Table 5.9. ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8526,45	2	4263,22	20,45	,000
Within Groups	26472,35	127	208,44		
Total	34998,80	129			

A Tukey HSD post hoc test was conducted to determine the specific groups that exhibited differences in individual innovativeness scores following the significant one-way ANOVA.

The results indicated that educators with more than 20 years of experience demonstrated significantly lower individual innovativeness scores compared to those with 0–10 years ($M = -17.35$, $SE = 3.12$, $p < .001$, 95% $CI [-24.75, -9.96]$) and those with 11–20 years of experience ($M = -17.50$, $SE = 3.13$, $p < .001$, 95% $CI [-24.94, -10.07]$).

Table 5.10. Post hoc test multiple comparisons dependent variable: Individual innovativeness Tukey HSD.

(I)Experience Years	(J)Experience Years	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
0-10	11-20	-,15	3,06	1,00	-7,41	7,11
	20+	17,35	3,12	,000	9,96	24,75
	0-10	,15	3,06	1,00	-7,11	7,41
11-20	20+	17,50	3,13	,000	10,07	24,94
	0-10	-17,35	3,12	,000	-24,75	-9,96
20+	11-20	-17,50	3,13	,000	-24,94	-10,07

The mean difference is significant at the 0.05 level.

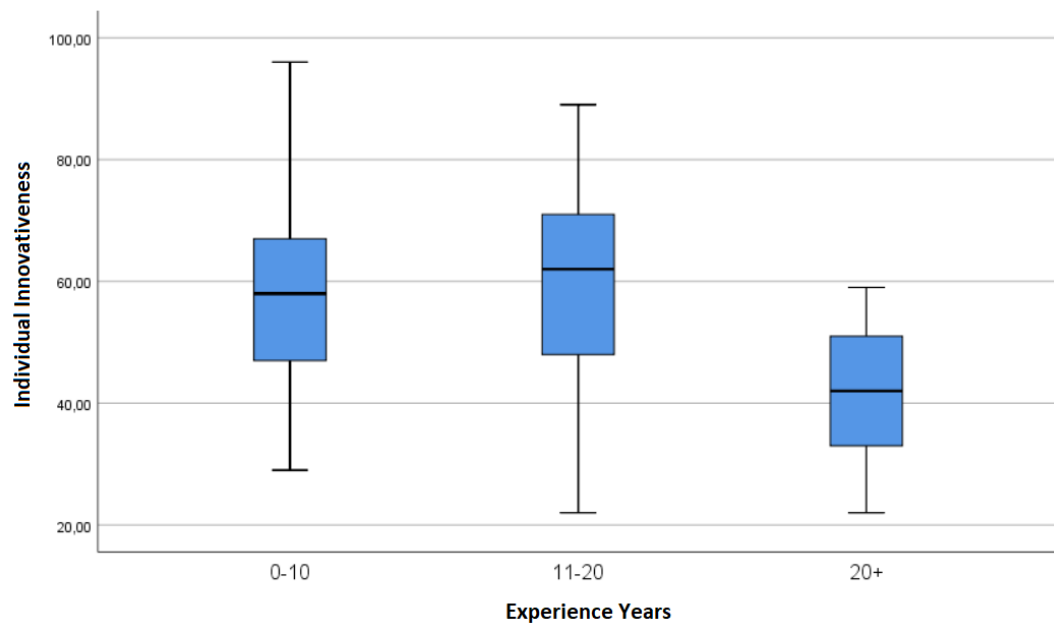


Figure 5.5. Boxplot of II scores.

No significant difference was found between educators with 0–10 years of experience and those with 11–20 years ($M = -0.15$, $SE = 3.06$, $p = 1.00$, 95% $CI [-7.41, 7.11]$).

The results demonstrate a significant decline in individual innovativeness scores among teachers with more than 20 years of experience relative to their less experienced counterparts.

5.3. Qualitative Part

For the qualitative part of the study, thematic analysis was conducted using the ATLAS.ti application. Interviews were transcribed, and codes were created using open coding. The codes were then grouped under appropriate predetermined themes. The Table 5.11 below shows the themes, codes, and definitions.

Table 5.11. Code descriptions.

Theme (Code Group)	Code	Description
Technology Budget	1. Budget Constraints and Priorities	How schools' economic resources shape technology use, licensing, and priorities.
	2. Impact on Pedagogical Planning	How income constraints and prioritization affect lesson plans, preparation, and teaching methods
Technology Ownership	3. Access to Personal and School Devices	Access to individual or school-supported digital tools for teachers and students
	4. Inequalities and Individual Effort	Differences in access to tools and dependence on individual efforts when integrating technology into education
Update Time for Technological Devices	5. Frequency and Quality of Updates	How to regularly and properly update and maintain digital tools/ software
	6. Technical Issues Affecting Teaching	Problems with slowness, crashes, inconsistencies and confusing factors that interrupt the lessons
The Number of Utilized Internet Applications	7. Variety and Choice of Applications	The range of software and tools teachers use to meet learning goals.
	8. Barriers to Effective Classroom Use	Challenges such as long preparation time, complicated interfaces, and language barriers
Internet Usage Habits	9. Frequency and Purpose of Internet Use	How often and for what purpose educators use the Internet
	10. Teacher Confidence and Integration Strategies	Teachers' comfort, self-efficacy, and teaching methods when integrating technology

The Figure 5.6 below shows the frequencies. It indicates how many times each code was mentioned in the interviews. Thus, this table can provide insight about the relative dominance and importance in relation to teachers' experiences.

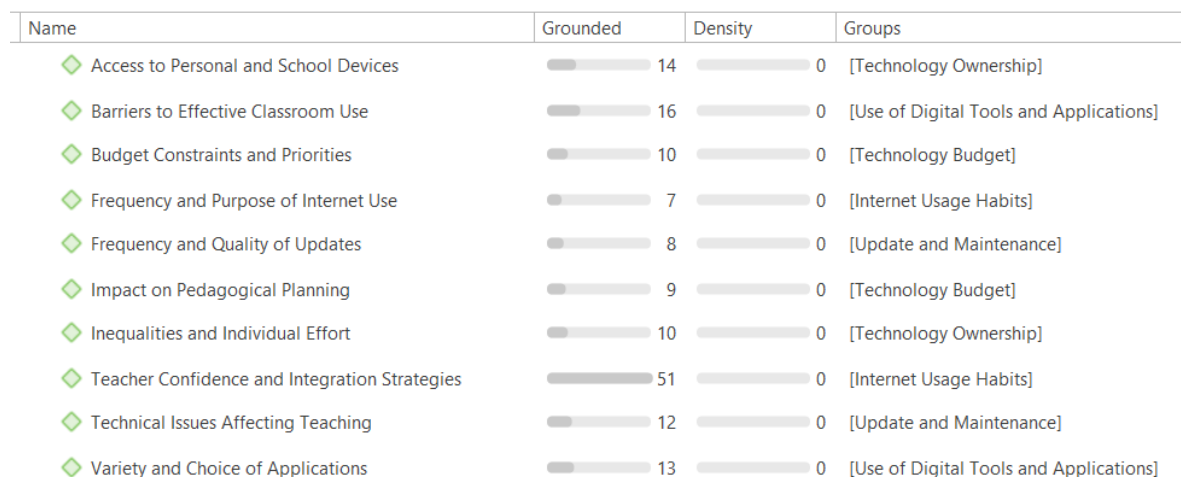


Figure 5.6. Frequency of Codes.

This part presents the qualitative results of semi-structured interviews. The participants included four middle school mathematics teachers who work in public and

private schools. Also these participants had different levels of Technological Pedagogical Content Knowledge (TPACK) and individual innovativeness (II). The aim of the qualitative phase of the study was to find out the ways of integrating mathematical tools, institutional facilitators and barriers and the experiences of participants in terms of their TPACK and Individual Innovativeness (II).

Participants' scores for technological pedagogical content knowledge (TPACK) and individual innovation (II) are illustrated in Table 5.12 below.

Table 5.12. The aspects of participants.

Participant	TPACK Maksimum=165	Individual Innovativeness (II) Maksimum=80	School Type
Participant 1	155	75	Public
Participant 2	62	27	Public
Participant 3	157	76	Private
Participant 4	61	28	Private

5.3.1.Theme 1: Technology Budget

The Technology Budget theme showed income differences in terms of integration of the technology into mathematics lessons. Although access to funding seemed to significantly facilitate the effective integration of technology, its impact was limited by the teachers' motivation, pedagogical vision, and perceived efficacy.

Codes are in this theme;

- Budget Constraints and Priorities (10)
- Impact on Pedagogical Planning (9)

5.3.1.1. Budget Constraints and Priorities. This code covers how funding limitations or high budgets affect mathematics teachers' technology access, licensing, maintenance, and planning. Mathematics teachers within the sample mentioned the influence of financial income on their use of technological resources. The code was repeated ten times.

The mathematics teacher with low TPACK and II in public school highlighted limited, centrally governed budgets that can not be changed by their choices:

“There is a scarce additional budget for technology at our school. Generally, we must wait for assistance about the issues of smart boards from higher status.” (Low TPACK & Low II, Public)

This answer shows that when resources are limited, teachers may think of budgets as rigid and set by outside forces. Because of this, they may be less willing to integrate technology. Weak TPACK and innovative abilities may make teachers less motivated to work within economically negative limits.

However, mathematics teachers with high TPACK and individual innovativeness were more active and flexible in how they used resources even in public schools with limited budgets:

“Even though we have limited opportunities, I'm carefully planning to utilize free resources. While it's not feasible to provide a device to every student, I show them via smartboard.” (High TPACK & High II, Public)

Mathematics teachers with higher TPACK and II in private schools emphasised their schools' perception to integrate technology through strategic budgeting.

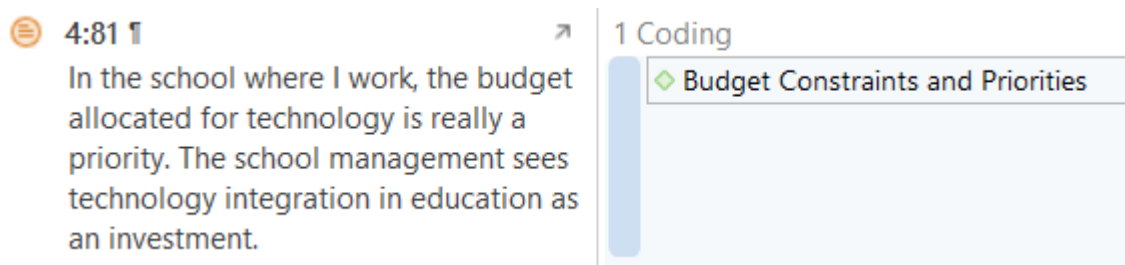


Figure 5.7. Quotation (High TPACK & High II, Private).

Proactive institutional policies provide that teachers implement lessons that develop both students and teachers with technology supported environments. However, mathematics teachers with low TPACK and II may fail to utilize these resources effectively, even at well-funded private institutions.

“Even though technically the system is feasible, I hesitate to use it effectively. Relying on previous already known information seems more appropriate.” (Low TPACK & Low II, Private)

The response indicates that receiving technological resources alone is not enough. Even high budgets might not help to integrate technology effectively if there isn't strong TPACK and individual innovativeness (II).

5.3.1.2. Impact on Pedagogical Planning (9 Occurrences). This code examines influences of funding on teachers' lesson preparation, planning, and pedagogical choices. It was repeated nine times.

Mathematics teachers in private schools, especially those exhibiting high TPACK and innovativeness, indicated strong institutional background for the obtaining and utilization of technological resources. Participant 3 emphasized their supportive institutional policy about budget allocation:

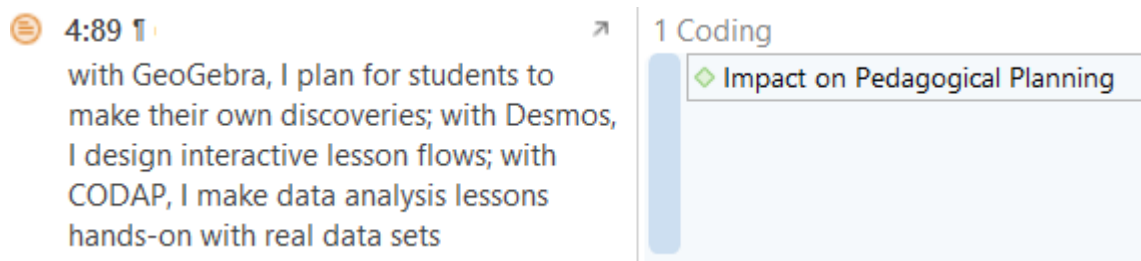


Figure 5.8. Quotation (High TPACK & High II, Private).

The findings showed that the financial assistance helps the participants to design student-centered and technology-integrated mathematics lessons. The presence of interactive platforms showed the importance of financial support in both experimentation

and instructional significance. If students do not have devices, these activities may be limited with teacher demonstration on smartboard.

On the other hand, Participant 4 showed a tendency towards underutilization although strong access and facilitation are available:

“Technically, everything is feasible, but considering how to enhance pedagogical effectiveness seems like a waste of time to me. Because using digital tools requires preparation before the lesson and if I am not able to manage the class during the lesson, it can be only. ” (High TPACK & High II, Private).

This statement demonstrates that even in well-funded settings, a deficiency in pedagogical confidence or resistance to embrace innovative methods can hinder the effective utilization of resources. In such instances, the budget functions as a hidden factor rather than a proactive driver of innovation.

Mathematics teachers who work at public schools had a more limited perception of the technology integration. Participant 1 emphasized the curriculum expectations from students about the use of digital tools like GeoGebra. However, Participant 1 also drew attention to the fact that students can't use them in class:

"Although the curriculum and books which are published by the Ministry of National Education encourage interactive dynamic mathematical tools especially like GeoGebra, unfortunately students are not able to use them actively during class. I think, only showing and using these tools by the teacher decreases the students' enthusiasm and exploration." (High TPACK & High II, Public)

Although Participant 1 had high personal abilities and competencies and was enthusiastic to integrate technology in mathematics lessons, their efforts stayed limited due to lack of funding and access for students.

On the other hand, Participant 2 mentioned feeling disconnected to integrating technology and embracing new methods in the mathematics lessons. A lack of

technological abilities, low level of pedagogical knowledge as well as inadequate funding were shown as an excuse and cause of internal uncertainty and resistance to change:

"Even if I had a budget and high facilitation, I wouldn't know how to integrate technology into mathematics lessons effectively. So I usually benefited from traditional methods and tools I knew previously." (Low TPACK & Low II, Public)

This part shows how external factors which are low levels of budget from institutions, and internal factors which are feeling confident and capable in digital abilities, can intersect and provide strands negatively in terms of innovation and technological integration in mathematics lessons. Therefore, the lack of abilities, facilitation, and inadequate support not only lead to low level and ineffective use of resources, but these factors may also make teachers more dependent on traditional teaching methods and push them to use the outdated tools which they have already known.

In conclusion, although the institutional budget significantly influences access to digital tools, its efficacy also depends on teachers' abilities. High TPACK and innovativeness empower educators to effectively benefit from available resources, while negative perception toward technology use and diminished self-efficacy may induce a decline in technology integration, even in resource-abundant settings. So, external and internal factors are crucially interdependent to determine the effectiveness of technology integration and innovative methods in mathematics lessons.

5.3.2. Theme 2: Technology Ownership

The theme of Technology Ownership focuses on the diversity and volume of technological devices that educators personally own and utilize for instructional purposes. Analysis indicated that personal access to technological tools such as laptops, tablets, and interactive devices significantly affected the extent of digital resource integration in classroom practices. Ownership alone was insufficient for meaningful integration. Competence and pedagogical vision are also equally crucial.

Codes are in this theme;

- Access to Personal and School Devices
- Inequalities and Individual Effort

5.3.2.1. Access to Personal and School Devices. Teachers are examined based on their own access to resources, both personally and within their institutions. It was repeated 14 times.

Mathematics teachers in public schools reported varying experiences depending on their individual profile. Participant 2 highlighted the restricted institutional resources and need for relying on personal devices for even the simplest preparations:

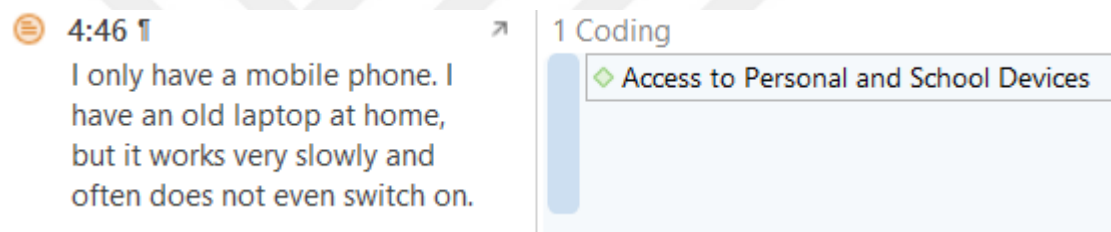


Figure 5.9. Quotation (Low TPACK & Low II, Public)

This dependence on personal devices shows inadequate systematic access. Participant 1 indicated utilizing personal devices to reduce the deficiency of institutional infrastructure:

"We don't have devices at school, but I use my own laptop and phone to plan activities for students. These are essential for me to prepare for class." (High TPACK & II, Public)

This response shows that the teacher uses personal technology to plan interactive, student-centered lessons even though the institution doesn't provide any.

Conversely, mathematics teachers in private schools asserted they had high access to school-provided resources.

"A laptop is given to every new teacher. The school updates them often. And we can receive lots of interactive applications to enhance lessons." (High TPACK & II, Private)

Via high institutional support, mathematics teachers with high TPACK and II can plan lessons effectively and interactive materials.

On the other hand, even in well funded private schools mathematics teachers with low TPACK and low II, may only used it for simple goals:

"I have a laptop, but I mostly use it only to study for tests or give presentations." (Low TPACK & Low II, Private)

This shows that having access to well funded resources is not enough on its own. For integration to work, teachers need to know deeply about how to teach and be willing to try new things.

To summarize, improving adequate access to institutions is important. However, its outcomes depend on how mathematics teachers' TPACK and innovativeness vary. Teachers with high TPACK and II can change even limited resources into chances for student-centered learning. Conversely, teachers who aren't good at both abilities may stick to traditional classical methods even in well funded environments.

5.3.2.2. Inequalities and Individual Effort. This code shows how varying students' access is and teachers' efforts to develop teaching. It was repeated ten times.

Mathematics teachers possessing high TPACK and Individual Innovativeness (II) consistently exhibited significant ownership and intentional utilization of personal technology. Participant 3 articulated a comprehensive array of tools available to them:

"I utilize my personal laptop, iPad, and even a graphics tablet. I can prepare lesson plans and give assignments with interactive materials by uploading them. Students do not have difficulty accessing it." (High TPACK & High II, Private)

This participant illustrates how personal access facilitates both lesson preparation and exploration with advanced tools. The availability of various devices facilitated the exploration of interactive materials for conceptual mathematics instruction.

Conversely, Participant 1 similarly indicated utilizing personal devices to reduce the deficiency of institutional infrastructure:

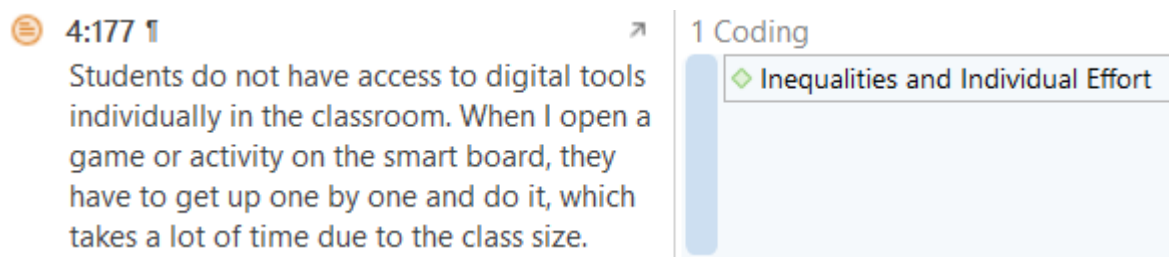


Figure 5.10. Quotation (High TPACK & High II, Public),

This quote highlights a complex discovery. Ownership can enhance teachers' personal competence and motivation, yet its complete instructional effect depends upon the technological preparedness of the learning environment. The teacher's intrinsic ability is consequently only partially engaged without corresponding support for student access.

Conversely, mathematics teachers exhibiting low TPACK and low innovativeness displayed restricted ownership and negligible engagement. Participant 2 remarked:

"I possess an outdated laptop at home, but its performance is excessively slow. I rarely use my phone for teaching, though I do use it most of the time. I lack confidence in my ability to create digital content. Even if I used it, it wouldn't be useful because the students don't have access to it." (Low TPACK & Low II, Public)

The absence of both devices and inability of digital integration results in near-total disengagement from digital pedagogy. The participant neither experiments with nor adopts new tools, demonstrating how insufficient technology ownership, combined with low technological ability and inability to receive digital resources constitutes a substantial obstacle to innovation.

On the other hand, Participant 4 (Low TPACK & Low Innovativeness, Private), despite possessing advanced devices, expressed comparable reluctance:

“I have the devices, but I do not perceive myself as someone capable of easily adapting to new technologies. I prefer writing with a pen and white boards.”

This statement underscores a crucial nuance: even in resource-abundant private school environments, educators with a diminished technological proficiency may refrain from incorporating digital tools, irrespective of their availability.

In conclusion, the theme of Technology Ownership underscores that the possession of devices facilitates technology integration solely when accompanied by a proactive and assured pedagogical approach. Educators equipped with both hardware and high TPACK/innovativeness are more inclined to integrate technology effectively into their instruction. Conversely, individuals with restricted ownership or diminished technological ability often omit technology from their instructional practices. By demonstrating that ownership is a crucial though not the only factor in the effective use of dynamic mathematical tools in mathematics education.

5.3.3. Theme 3: Update Time for Technological Devices

The theme Update Time for Technological Devices examines the frequency with which educators or their institutions upgrade or replace technological tools and the impact of this on their instructional methodologies. The analysis indicated that prompt updates whether of hardware (e.g., laptops, tablets) or software (e.g., educational platforms, app versions) are essential for maintaining compatibility, reliability, and pedagogical effectiveness. The efficacy of these updates is intrinsically connected to the teacher's TPACK proficiency and receptiveness to innovation.

Codes are in this theme;

- Frequency and Quality of Updates
- Technical Issues Affecting Teaching

5.3.3.1. Frequency and Quality of Updates. Participants described important differences in how regularly and thoroughly their school systems updated technology. It was repeated 8 times.

The mathematics teacher in public school with low TPACK and II said that systems were old and not well taken care of:

"Smart boards have been using the same system for years. Maintenance is slow and not very thorough. Also, not even the photocopier works. It makes me reluctant when integrating technology in my lessons." (Low TPACK & Low II, Public)

This limited updating slowed down lessons, and decreased motivation to plan lessons interactive activities. Low TPACK made it hard for teachers to adapt, and low innovativeness made them reluctant to solve problems instead.

Even though they were working with a similar budget, the mathematics teacher in public schools with high TPACK and II responded in different ways.

"I regularly update the applications on my own tablet and laptop to prepare content, but the school devices are old. Students are limited from engaging with similar applications during class." (High TPACK & High II, Public)

Even though mathematics teachers try to stay up to date, if the lack of widespread device renewal across the institutions exists, the use of technology integration into the mathematics lessons may stay limited and it can lead to decrease in active use of mathematical applications by students.

Participants exhibiting high TPACK and individual innovativeness characterized their behavior as systematic and proactive in updating, both on an individual and institutional level. Participant 3 articulated a systematic update procedure supported by institutional policy:

“Every year, the IT department plans updates and gets feedback. I do not have difficulty in integrating digital tools that I want in my lessons.” (High TPACK & High Innovativeness, Private)

This practice guarantees that teachers function within a consistent, up-to-date technological framework, enabling them to maximize the capabilities of applications. Regular updates eliminate technical obstacles, facilitating innovative educators in planning and delivering interactive, contemporary lessons aligned with TPACK components.

On the other hand, Participant 4 reiterated this sentiment, despite being in a resource-abundant institution:

“The school updates everything annually, but I adhere to the previous versions of mathematical applications in my personal devices. I become overwhelmed and have difficulty getting used to new versions when there are excessive changes.” (Low TPACK & Low II, Private)

This response indicates that frequent updates may induce anxiety if not accompanied by adequate training or intrinsic motivation. The existence of current tools becomes meaningless if the user lacks adaptability or perceives no educational engagement in the modifications.

Mathematics teachers possessing high TPACK and innovativeness levels not only value regular updates but also utilize them to improve instructional design with digital tools. Conversely, infrequent updates or hesitation to adopt new versions frequently signify or promote diminished digital confidence and reluctance to pedagogical transformation. The results show that staying up to date on new technologies and internal factors to follow them plays an important role. The intersection of external and internal factors helps to come up with the use of new educational applications in the mathematics lessons.

5.3.3.2. Technical Issues Affecting Teaching. Participants further discussed technical issues such as slowness, crashes, lack of internet connection, and confusing interface. It was repeated 12 times.

For the technical problems, public school teachers with especially low TPACK and II got angry and avoided personal effort:

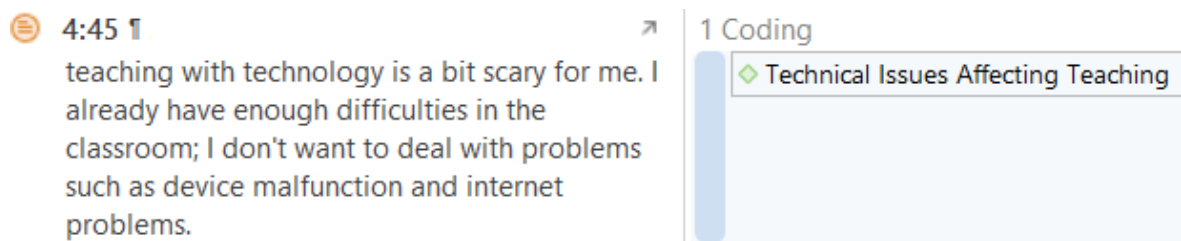


Figure 5.11. Quotation (Low TPACK & Low II, Public).

Teachers with low TPACK and II may see technical problems as factors that force them to use traditional methods. Their low TPACK may prevent them from fixing problems, and their low innovativeness may induce less willingness to try new things or adapt.

Mathematics teachers in private schools with high TPACK and II emphasized different but related problems. Even though their infrastructure was strong, software updates were stressful for them:

"When new versions come out, the interface changes. It's hard for me to keep up. So I'd rather use the old method I know." (Low TPACK & Low II, Private)

In this case, the issue wasn't a lack of updates; it was difficulty in the mental effort of having to adjust to changes.

Conversely, mathematics teachers with high TPACK and II said that technical problems were normal challenges that could be dealt with:

"You have to get ready, but it's worth it. Before class, I generally test applications and make sure that tasks and design are appropriate for students to use. Also, if the internet goes down, I usually have a copy that I can use without an internet connection." (High TPACK & High II, Private)

When high TPACK, II and facilitations are combined, teachers can see technical issues as problems that could be solved.

On the other hand, even if teachers have high TPACK and innovativeness, they may feel unmotivated because of technical issues.

"Sometimes I can not turn it on due to a fault in the smartboard. And I do not have a chance to use a photocopy machine. Therefore, I need to take the copies from my personal printer before the lesson." (High TPACK & High II, Public)

This shows problem-solving and a strong desire to support teaching even when there are difficulties.

Technical issues are a problem for everyone. However, how teachers deal with them depends on their willingness, TPACK and innovativeness levels. When technical issues, low TPACK and lack of innovativeness and reluctance can accumulate; it can cause frustration, avoiding new ideas, and sticking to classical traditional ways of doing things. Conversely, high TPACK and high innovativeness help teachers to plan, fix problems, and make designs that are flexible. This keeps learning interactive even when intentions aren't going as planned.

These results show that teachers need to be trained, promoted with the technical tools and supported in order to gain the technological knowledge, confidence, and flexibility for meaningful integration.

5.3.4.Theme 4: The Number of Utilized Internet Applications

The Number of Utilized Internet Applications theme examines the different types of internet tools that mathematics teachers use and how often they use them. The narrations of the participants showed a strong relationship between the number of digital memberships and tools they used and the level of TPACK and innovativeness.

Codes are in this theme;

- Variety and Choice of Applications
- Barriers to Effective Classroom Use

5.3.4.1. Variety and Choice of Applications. There are big differences between the number and range of applications mathematics teachers used to help students reach educational goals. It was repeated 13 times.

Participants 1 and 3, who had high levels of TPACK and high individual innovativeness (II) used a variety of internet-based applications effectively. The results also showed that they (Participants 1 and 3) were using internet applications in a planned and pedagogically efficient way. Participant 3 said,

"I especially use GeoGebra, Wordwall and Kahoot based on the content. Also students sometimes utilize Codap to analyze graphs and create their own. Using CODAP, students can upload authentic datasets and conduct real-time statistical analyses." (High TPACK & High II, Private)

This example illustrates how a varied array of applications not only improves student engagement and conceptual comprehension but also empowers mathematics teachers to create dynamic, interactive learning environments. The mathematics teachers who have high TPACK and Individual Innovativeness (II) use various tools in a deliberate way. The use of them is also rooted in educational objectives. Although mathematics teachers who have high TPACK and Individual Innovativeness (II) differ by institutional resources and training, internal enthusiasm and engagement plays a crucial role.

Participant 1 demonstrated widespread use, although in a less technologically restricted setting:

"I can employ GeoGebra, Kahoot, Wordwall, Edpuzzle, and occasionally CODAP. These instruments enhance engagement and comprehension. However, due to the lack of device access for students during class, I frequently must deliver content independently." (High TPACK & High II, Public)

The quantity of tools employed indicates digital proficiency and an aspiration to develop multi-modal learning experiences. Nonetheless, restricted student access destroys the interactivity and communal experience that these tools aim to facilitate.

In contrast, participants exhibiting low TPACK and low levels of Individual Innovativeness (Participants 2 and 4) indicated limited or reluctant utilization of internet applications. Participant 2 (Public) acknowledged:

"I exclusively utilize EBA. I do not need any alternative applications."

This indicates a limited perspective on digital tools, viewing them as insignificant.

Participant 4 stated also conveyed hesitance to investigate beyond fundamental tools:

"I previously looked at GeoGebra and Codap. But I do not like using them and prefer to use a whiteboard to illustrate the content." (Low TPACK & Low II, Private)

Despite possessing institutional access to various tools, the teacher's diminished digital self-motivation constrained their actual utilization. The mere existence of technology did not result in its application. It is also important to underscore the significance of mindset and perceived usability.

This section illustrates that the variation in application usage is influenced not only by school resources but also by mathematics teachers' motivation, TPACK and II. Insufficient TPACK, lack of innovativeness, unwillingness and inadequate institutional support frequently induce mathematics teachers to a limited selection of familiar tools. High TPACK and II empower teachers to assess, choose, and incorporate various tools that align with educational objectives. And it directly fosters student engagement and facilitates significant learning experiences based on mathematics teachers' experiences.

5.3.4.2. Barriers to Effective Classroom Use. Mathematics teachers asserted practical obstacles that hindered their capacity to utilise technology effectively in the classroom. It was repeated 16 times.

Teachers with low TPACK and low innovativeness scores cited preparation time, interface complexity, and management issues as justifications for not integrating technology.

“Understanding and preparing technological tools requires time. Also, the internet connection is exceedingly slow. So I prefer classical methods to teach.” (Low TPACK & Low Innovativeness, Public)

The teacher saw problems as too challenging to solve. So traditional methods seemed more predictable and easier to handle.

Even in private schools, the teacher with weak TPACK and weak innovativeness reported lack of technology integration due to the additional cognitive demands.

“Utilising digital tools necessitates prior preparation before the lesson. Also, if I am unable to control the class during the lesson, it simply fails to function.” (Low TPACK & Low Innovativeness, Private)

“With the new versions, the interface of applications provides modifications and it leads to confusion. Majority of mathematical applications are in English and excessively difficult for me to comprehend.” (Low TPACK & Low II, Private)

This indicates a limited perspective on digital tools, viewing them as burdensome and insignificant, particularly when not provided in the mathematics teachers’ primary language. The participant's technological repertoire is influenced not by pedagogical alignment, but by comfort and familiarity.

In contrast, mathematics teachers with high TPACK and II regarded these barriers as planning challenges to be addressed.

“Preparation is tiring, yet it is worthwhile. I examine applications prior to class and create homework to facilitate student usability.” (High TPACK & High Innovativeness, Private)

This point of view shows how having high TPACK and high II can help mathematics teachers see problems as challenges that can be overcome with careful planning and design. These teachers actively change technology to support student-centered learning, which shows how important it is to know how to teach and be open to new ideas.

This theme can be an indicator of teachers' competence in integrating technology and their innovativeness. Results showed that teachers with high TPACK and high individual innovativeness were more likely to choose from a wide range of apps based on pedagogical and content-related fit for their instruction. Conversely, teachers with low TPACK and individual innovativeness were tied to a limited number of familiar platforms because disrupting their routines could lead to anxiety and feelings of inadequacy. Professional assurance, curiosity, and practice can help integrate a wider range of apps into lessons more effectively.

5.3.5. Theme 5: Internet Usage Habits

The theme of “Internet Usage Habits” examined how frequently mathematics teachers use the internet for educational purposes, how they integrate teaching methods into their lessons, their feelings about using the internet for educational purposes, and any problems they encounter. As a result, differences were observed among teachers' experiences. These differences are related to teachers' digital self-motivation, access to technology at school, and professional mindset.

Codes are in this theme;

- Frequency and Purpose of Internet Use (7 times)
- Teacher Confidence and Integration Strategies (51 times)

This part combines two aspects of teachers' internet usage habits that are closely linked: how often and why they use online resources, as well as their confidence in using them and their methods for doing so. That's why, these aspects are examined together to keep the natural flow and meaning of their answers

5.3.5.1. Frequency, Purpose, and Teacher Strategies. Participants 1 and 3, who had TPACK and Individual Innovativeness (II), used the internet in a consistent and intentional way. In other words, the use of the internet for them goes beyond just getting content. Participant 1 (High TPACK & Individual Innovativeness, Public) said:

"I usually create my lesson slides by using Canva. Also I incorporate tools links such as GeoGebra, Wordwall, and Codap in the related slides. Before the lessons, preparing these online settings enhances my time management during class and it also increases lesson efficiency."

This statement shows a strategic way to use the internet which is beyond getting resources. It makes lessons more structured and interactive. The participant's continued use of different platforms shows that they are thoughtful about the preparation phase. And it is also related to digital pedagogical awareness.

Participant 3 also showed that they actively use the internet:

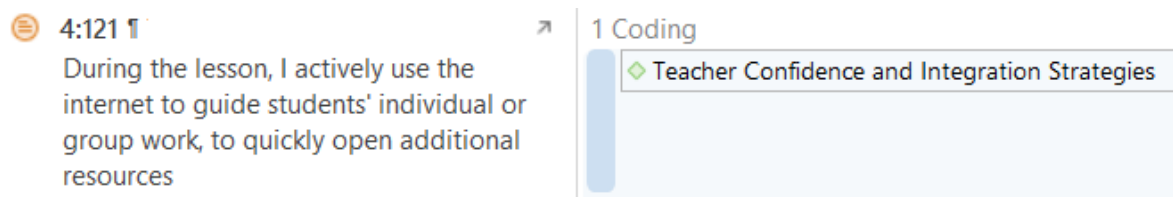


Figure 5.12. Quotation (High TPACK & High II, Public).

Using the internet in all phases of the lessons shows when the internal factors which are enthusiasm, high TPACK and innovativeness and external factors which are institutional support intersect, proactive use of internet increases and student engagement enhances based on teachers' experiences.

On the other hand, participants with low TPACK and Individual Innovativeness (Participants 2 and 4) said they didn't use the internet very often or very deeply. Participant 2 said,

"I use the internet about once or twice a week for educational purposes. And it is mostly to look for worksheets or sample test questions. I don't trust online tools and usually rely on what I already know. Because they can be risky and time consuming during the class." (Low TPACK & Low II, Public)

This limited use of the internet shows that the internet is seen as a way to get only content. It is not internalized as a place to come up with new ways to learn. In mathematics teachers who have low TPACK and weak Individual Innovativeness (II), depending on familiar methods, reluctance about the internet limits the power of online resources to change things.

Participant 4 asserted,

"I mostly use the internet to look up questions and watch videos. I don't use it interactively in the lessons with students because it can also may cause management problem and lose in topic focus" (Low TPACK & Low II, Private)

Even though this participant works in a place with a lot of resources, active use of the internet and digital resources is not preferred. The unwillingness to use and interact shows a lack of confidence in managing digital tools during class. It could be because they aren't used to them or are afraid of losing control of the classroom.

All of these results point to the fact that access and institutional policy do not alone determine how mathematics teachers use the internet. Instead, it is also related to their attitudes, enthusiasm, pedagogy and educational goals. Teachers who have high TPACK and Individual Innovativeness (II) use the internet to plan, carry out, and improve lessons. Also, it helps that digital resources are in line with what students are supposed to learn. Mathematics teachers who aren't very good at using the internet may see it as an extra time-consuming activity. To improve the use of the internet in mathematics education, it may be crucial to help teachers develop digital pedagogical mindsets as well as focusing on technical skills.

This part presented the qualitative results of semi-structured interviews. They had different backgrounds in terms of school type (public/private), levels of Technological Pedagogical Content Knowledge (TPACK), and Individual Innovativeness (II). The goal of the qualitative phase was to find out how teachers think about, comprehend, and use technology in their mathematics teaching. And, how well these practices fit with their TPACK and levels of innovativeness is examined in this part. The study also investigates how teachers reflect institutional support on using digital tools in mathematics lessons. Thematic analysis to code and group participant responses in five main themes: Technology Budget, Technology Ownership, Update Frequency for Technological Devices, Quantity of Utilized Internet Applications, and Internet Usage Patterns. The analysis gives a full picture of the situation and helps understand the factors that help or damage effective technology integration.

6. DISCUSSION

6.1. Correlation Between TPACK and Individual Innovativeness

The results of the study revealed a strong positive correlation between mathematics teachers' TPACK and individual innovativeness ($r = 0.63$, $p < .001$). This means that mathematics teachers with higher innovativeness characteristics are more likely to have higher technological pedagogical content knowledge. And vice versa. The results supported the idea that innovative teachers can adapt to technological changes more easily because they accept innovations more easily (Lai & Chen, 2011; Lee & Tsai, 2010; Öztürk & Çakıroğlu, 2022; Shin et al., 2009).

Mathematics education in today's educational world, innovative features play a very important role in enabling teachers to follow technological developments and improve themselves by applying them. Therefore, providing training for preservice and in-service teachers allows them to apply technology not only in theory but also in practice. Supporting their innovativeness, and encouraging the use of digital tools can improve the quality of mathematics education. Furthermore, identifying and taking prevention to control environmental factors that limit technology use in education is crucial for maintaining a balanced comprehension of technology pedagogy and content knowledge. For example, if an individual with high innovativeness struggles to access innovations due to environmental factors, this can undermine both their innovativeness and their desire and confidence in using technology.

Balancing both internal factors such as teachers' motivation, desire, and self-confidence and external factors such as access to technology and institutional support can enhance mathematics teachers' both TPACK and individual innovativeness characteristics.

6.2. Gender Differences in TPACK and Innovativeness

This study revealed that there was no significant difference in the TPACK and individual innovation characteristics of mathematics teachers based on the gender variable.

These results are consistent with some studies in the literature indicating that gender is not a determining factor in TPACK and individual innovativeness characteristics (Jamieson, Albion & Finger, 2010; Rogers & Wallace, 2011).

Ertmer et al., 2022 stated that gender was more important in education in the past, but thanks to the developing conditions and increasing opportunities, factors such as school environment, institutional support and professional development are now more crucial than gender. Therefore, professional development programs that aim to increase TPACK and individual innovation can plan based on the problems and challenges faced by mathematics teachers, regardless of gender.

6.3. Differences Based on Years of Teaching Experience

The study revealed a significant difference based on the years of teaching experience among mathematics teachers. The results indicated that mathematics teachers with 20 or more years of experience had significantly lower TPACK and individual innovativeness scores compared to teachers with 0-10 and 11-20 years of experience.

This finding supports previous research that showed difficulty in helping experienced teachers adapt to changes about technology (Harris, 2016; Mouza et al., 2017). Teachers who started their careers before the digital age may not have received any training regarding the use of technology in the classroom. And they may have developed traditional teaching methods that are difficult to change.

This points how important it is to establish professional development programmes, especially for mathematics teachers with higher teaching experience years. Thus, combining their deep existing knowledge and experience with new ways of using technology can produce much more effective teaching methods.

6.4. Insights from Qualitative Findings

The qualitative part of the study supports and reinforces the quantitative results. The results of the interviews with four middle school mathematics teachers from different

school types and with different levels of TPACK and Individual Innovativeness (II) were analysed in five main themes.

Technology Budget: Private school mathematics teachers with high technological pedagogical content knowledge (TPACK) and individual innovativeness (II) benefited from their schools' investments in licensed software, regular upgrades, and professional training. On the other hand, mathematics teachers with both high and low TPACK and Individual Innovativeness (II) in public schools demonstrated that students couldn't use the devices as much as they wanted, even though the curriculum encouraged the use of interactive tools. These results are in line with the study's finding that economical restrictions are still the first order obstacle (Castañeda et al., 2022). Integration is hindered by the absence of funding for software licenses, updates, or teacher training, even when initiatives offer fundamental infrastructure (e.g., smartboards).

What is more important, budget alone is not enough. Even in well-funded settings, mathematics teachers who did not have high TPACK and Individual Innovativeness (II) did not benefit from the resources they had. So thoughts about the complication or difficulty for use of digital tools are also important as well as digital infrastructure. This supports the idea that teachers' knowledge, attitudes, and openness to innovation are crucial second-order barriers (Tondeur et al., 2016).

Even in settings with limited funding, teachers with high TPACK and innovativeness made creative use of the resources at their disposal. It supports the claim that teachers' ability to modify technology to meet pedagogical objectives is a prerequisite for successful integration (Koehler et al., 2014; Voogt et al., 2017).

Increases in funds alone are not enough to improve technology integration. To optimize the pedagogical potential of available resources, policies should also encourage professional development that develops TPACK and cultivates an innovative mindset in mathematics teachers.

Technology Ownership:One key facilitator of technology integration has been identified as teacher and student device access. Based on recent studies on one-to-one

access, teachers who have their own laptops or tablets may be able to prepare lessons more flexibly, experiment with new tools, and modify materials outside of school hours (Lim et al., 2021). Teachers with high levels of technological pedagogical content knowledge (TPACK) and individual innovativeness (II) use laptops, tablets, and graphic tablets for preparing activities, assessing processes and integrating them in the lessons. This reinforces TPACK's focus on making informed decisions by comprehending how pedagogy, technology, and content intersect (Mishra & Koehler, 2006; Koh et al., 2022). But even the best efforts and enthusiasm can be destroyed if students do not have adequate access. For example, public school mathematics teachers often plan interactive lessons. However, they cannot implement them in the classroom as planned. On the other hand, teachers who did not have a high level of technological pedagogical content knowledge (TPACK) or individual innovativeness (II) often did not have the latest devices. Since they did not prefer not to use them for teaching even if they were available. This supports research showing that pedagogical capacity and access require being combined (Blonde et al., 2022). So this draws attention to the holistic need for mathematics teachers' efforts and equitable students' access to the digital resources.

Ensuring device access should be a priority for professional development. To go beyond simple substitution and towards meaningful integration, it is essential to develop pedagogical strategies for technology use.

Update Time for Technological Devices: Maintaining technology integration has been shown to demand regular updates and maintenance. A study that focused on system-level support found that private schools with well-organised, responsive update systems made integration easier for teachers (Ifinedo et al., 2020). Schools and teachers with high technological pedagogical content knowledge (TPACK) and individual innovativeness (II) regularly and methodically updated their hardware and software. The common aspect of the mathematics teachers with high TPACK and II in both public and private schools is the thought that updates improve their teaching and help to catch the needs of today's students. As noted by Hargreaves and Fullan (2020), this flexibility is essential for the necessity of instruction that fosters a sense of ease with constant technological change. On the other hand, teachers who were not very innovative and did not have high technological knowledge often turned down updates, saying they were too complicated or they were

afraid of change, even if schools required them to do so. This is consistent with research showing that the influence of technical systems is mediated by teachers' self-efficacy and adaptability (Ertmer et al., 2020).

Updating software and maintaining devices are essential but insufficient. Schools should combine ongoing teacher development that fosters adaptive expertise and decreases change anxiety with technical maintenance.

Number of Utilized Internet Applications: Teachers with high levels of technological pedagogical content knowledge (TPACK) and individual innovativeness (II) used a wide range of online tools. It helps to adapt their choices to meet specific educational goals. Examples include the use of Wordwall and Kahoot for engagement, GeoGebra for dynamic geometry and CODAP for realistic data analysis. Based on research, teachers' technological knowledge influences the quality of integration (Tondeur et al., 2017), and this deliberate, goal-oriented selection is an essential aspect of TPACK (Koehler et al., 2014).

On the other hand, teachers with low TPACK and innovativeness often stuck to a single platform such as Education Information Network (EBA), which was often necessary because they were concerned about how difficult or confusing other tools might be to use. This is consistent with recent research showing that attitudes and beliefs maintained by teachers continue to be significant obstacles to the adoption of more interactive tools (Castañeda et al., 2022).

Large class sizes and a lack of student devices were two systemic obstacles that even mathematics teachers with high TPACK and II had to overcome in order to increase individual interaction with these tools. It highlights the ecological complexity of technology integration (Blonder et al., 2022; Zhao & Frank, 2003). Also another factor for them to think that it would be difficult to use is that the language of such digital applications is generally English, and they are not able to comprehend it.

Helping teachers assess and incorporate tools pedagogically requires professional development that goes beyond tool training. To make sure that student access and class

sizes facilitate interactive, student-centered teaching methods, educational institutions should also think about implementing structural changes.

Internet Usage Habits: Disparities in internet usage were particularly noticeable. Teachers with low TPACK and low innovativeness frequently used the internet only as an alternative goal (Puentedura, 2006). Teachers who had high technological pedagogical content knowledge (TPACK) and individual innovativeness (II) used the internet a lot and in conscious ways. It helps them to plan lessons, teach them, and evaluate after class. Their work demonstrates adaptive, responsive teaching and is in alignment with the SAMR model's redefinition stages (Puentedura, 2006). Additionally, these mathematics teachers predicted obstacles by creating offline substitutes and modifying exercises to better suit the needs of their students. Proactive planning like this demonstrates the adaptive expertise and professional agency required for long-term integration (Blonder et al., 2022).

On the other hand, mathematics teachers with low technological pedagogical content knowledge (TPACK) and individual innovativeness (II) used the internet for a limited time, mostly to find worksheets or test questions. They saw internet usage as a secondary, not a primary, teaching tool. These differences point out that developing conscious use of the internet with educational aims and the level of TPACK and Individual Innovativeness plays a crucial role in enhancing mathematics teaching.

Teacher confidence, or their perception of their own ability to use online resources effectively in the classroom, is another crucial dimension that emerges from the findings. Mathematics teachers who exhibit low levels of TPACK and innovativeness frequently report feeling unconfident about their capacity to organise or oversee interactive activities. They mentioned their worries about losing control of the classroom, dealing with disruptive students, and not knowing how to modify materials to meet the needs of the students. The literature has extensively documented this pattern. One of the best indicators of the depth of technology integration is teacher self-efficacy (Bandura, 1997; Inan & Lowther, 2010).

These qualitative results strongly suggest that just giving teachers access to technology is not enough. Institutional support can be directly related to the teachers' confidence, motivation, and have a clear vision for how to teach.

6.5. Integration of Quantitative and Qualitative Findings

The combination of the study's quantitative and qualitative results provides an understanding of the interactions between institutional, contextual, and individual factors in the Technological Pedagogical Content Knowledge (TPACK) and Individual Innovativeness (II) levels of in-service middle school math teachers.

Teachers' TPACK and their individual innovativeness scores showed a strong, significant positive correlation ($r \approx .63$, $p < .001$). Based on the statistical finding, mathematics teachers who possess greater levels of technological pedagogical expertise are more likely to embrace new concepts. This is consistent with earlier studies showing that teachers' willingness to embrace technology-rich, student-centered pedagogies is significantly predicted by their level of individual inventiveness (Koehler & Mishra, 2009; Rogers, 2003; Hughes, 2005; Teo, 2009; Öztürk & Çakıroğlu, 2022).

However, by demonstrating how and why these relationships appear differently across teaching environments and teacher profiles, the qualitative results put this correlation in crucial contextual depth.

6.5.1. Systemic and Institutional Elements

It was evident from the qualitative interviews that infrastructure and institutional budget have a major enabling or limiting influence. Better institutional support, including modern smart boards, separate devices for teachers and students, frequent software updates, and prompt technical support, was consistently reported by teachers in private schools. Due to the practical obstacles to implementing technology-rich, interactive lessons were lessened by these systemic factors. For instance, Participant 3 (Private, High TPACK & II) explained how they can use digital tools like GeoGebra, CODAP, and Desmos to

create fully interactive lessons with the help of dependable infrastructure and innovative management.

On the other hand, budget-constrained public school teachers cited issues like shared computers, outdated smart boards, internet connection problems, and a lack of licenses for premium platforms. Even highly innovative and tech-savvy teachers mentioned sacrificing personal devices to make up for it, like creating lesson plans on their own devices and coming up with different ways to teach in crowded, under-resourced classrooms. This supports the conclusion reached by Ertmer and Ottenbreit-Leftwich (2010) that one of the main first-order obstacles to the integration of technology in schools is still infrastructure access.

6.5.2. Teacher Agency, Knowledge, and Beliefs

However, infrastructure by itself was not enough to ensure successful integration. The qualitative results emphasize how teachers' TPACK and II were influenced by their responses to institutional limitations. These obstacles were characterised as difficulties that needed to be overcome by teachers with high TPACK and II levels. In order to maximise the limited opportunities for student participation, Participant 1 (Public, High TPACK & II), for instance, stressed the use of personal devices to create interactive materials in spite of the absence of institutional devices.

This conduct is consistent with research demonstrating that innovative teachers are more self-reliant, daring, and flexible (Şahin, 2011; Rogers, 2003). In keeping with what Rogers (2003) refers to as "relative advantage" and "compatibility" with their pedagogical values, they also frequently see the benefit of devoting time to preparation in order to attain student-centered outcomes.

Regardless of the resources at their disposal, teachers with weak TPACK and innovativeness, on the other hand, tended to see obstacles as unchangeable and turned to more conventional, teacher-centered approaches. Teachers with low II and TPACK reported using technology sparingly (e.g., showing slides or videos) or mostly relying on lectures delivered on a blackboard, even in well-equipped private schools. They cited time

constraints, stress, or complexity as reasons for not pursuing deeper integration. This is consistent with research by Ertmer (1999) and more recent studies (Kaya & Aydın, 2021; Nguyen et al., 2021) that highlight teachers' self-efficacy, beliefs, and attitudes as important second-order barriers to meaningful technology integration.

6.5.3. Institutional Culture and Professional Development

Furthermore, the results indicate that teachers can overcome first-order (access) and second-order (belief) barriers with the help of professional development and institutional culture. Private school participants emphasized access to continuous training, organised professional development opportunities, and school cultures that encouraged experimentation and group projects. Participant 3 mentioned, for instance, the annual in-service training that focuses on creating interactive lesson flows and integrating new software. This is consistent with studies demonstrating that teachers' TPACK and willingness to innovate can be raised through professional learning communities and ongoing training (Voogt et al., 2013; Harris & Hofer, 2011; Niess, 2011).

Public school teachers, on the other hand, reported fewer official support. Even when they were inspired, they frequently encountered institutional cultures that discouraged experimentation or taking risks. For them, overcoming systemic limitations was largely dependent on personal initiative and dedication.

6.5.4. Interdependence of Factors

All factors considered, these results show how teachers' technological expertise, institutional resources, and personal creativity all influence technology integration. Infrastructure is a necessary prerequisite, but without teachers' TPACK and innovative dispositions that promote meaningful, student-centered use, it is insufficient. On the other hand, without sufficient systemic support, even highly skilled and driven mathematics teachers find it difficult to fully utilise the potential of technology.

This dynamic is reminiscent of frameworks like the Technology Acceptance Model (Davis, 1989), which highlights perceived utility (influenced by pedagogical beliefs) and

ease of use (facilitated by infrastructure and training) as adoption drivers. Additionally, it supports the core idea of the TPACK framework, which is that integrating technology effectively necessitates balancing and intersecting content, pedagogical, and technological knowledge (Koehler & Mishra, 2009).



7. CONCLUSION

Qualitative analyses supported the quantitative findings. The analysis showed that availability of resources, teachers' attitudes, thoughts, and teaching goals were also related to the use of technology in the classroom. Teachers with a low individual innovativeness and technological pedagogical content knowledge (TPACK) often may not prefer to use the tools available to them, even if they worked in well-resourced schools. This indicates that both 'first order' barriers which are infrastructure and 'second order' barriers which are beliefs, self-confidence and pedagogical vision need to be addressed.

These results can be very important for policymakers, school leaders, and academics who train teachers. Relevant professional development that encourages exploration can facilitate reflective practice and create professional learning communities. Thus, mathematics teachers can work together to improve mathematics education.

As a result, it is important to help teachers develop both TPACK and innovativeness. Because this can make students more successful in a world that is becoming more digital and data-driven. Investing in infrastructure and mathematics teachers can help to make mathematics education more engaging.

8. LIMITATIONS

This part of the study presents some limitations that should be taken into account when examining its results.

8.1. Sampling Method and Generalizability

In the quantitative phase of the study, a non-probability based convenience sampling method was used. In addition, most of the participants were found through online platforms and professional networks in Istanbul. This approach facilitated practical and timely data collection, yet it constrains the generalizability of the findings beyond the specific context of middle school mathematics teachers in Istanbul. Teachers in other parts of Turkey, particularly those in rural or underdeveloped areas, might experience different institutional barriers, varying degrees of technology access, or distinct TPACK and innovativeness patterns.

8.2. Sample Size and Representation

Despite the sample size ($N = 130$) for the quantitative phase, $n = 4$ for the qualitative phase) fulfilling the predetermined criteria for statistical analysis and thematic investigation, it constitutes merely a minor segment of Istanbul's total population of in-service middle school mathematics educators. The qualitative phase, comprising merely four participants, may inadequately represent the diversity of experiences and perspectives within the wider teaching community.

8.3. Self-Report Measures

TPACK and individual innovativeness were evaluated through self-reported Likert-type scales. Although these instruments have exhibited robust reliability and validity in previous studies, self-report measures may be influenced by social desirability bias, recall

inaccuracies, or distortions in self-perception. Consequently, the scores may not accurately represent teachers' true competencies or creativity.

8.4. Focus on Specific Tools and Framework

The research specifically analyzed technology integration utilizing the TPACK framework and concentrated on tools such as GeoGebra and CODAP. While these tools are important to mathematics education, their limited focus constrains the findings, as alternative technological tools or pedagogical frameworks may offer distinct integration challenges or opportunities that this research did not investigate.



9. RECOMMENDATIONS

This research concentrated on practicing middle school mathematics educators in Istanbul. To gain a deeper understanding of how context influences TPACK and innovativeness, future studies should involve educators from a variety of geographic locations, such as rural and underdeveloped areas. Comparative analyses across regions could guide the formulation of more equitable national policies.

The qualitative phase of this study provided valuable insights; however, the limited sample size ($n = 4$) constrains its transferability. Subsequent research may employ larger and more diverse samples for interviews or focus groups to encompass a broader spectrum of experiences and enhance comprehension of the obstacles and facilitators of technology integration.

Future research may investigate how differences in teachers' TPACK and innovativeness affect student outcomes, including engagement, conceptual understanding, problem-solving abilities, and attitudes toward mathematics. This research would strengthen the argument for investing in teacher development by establishing a direct connection to student learning outcomes.

This study concentrated on tools such as GeoGebra and CODAP however, subsequent research may investigate the incorporation of emerging technologies, including learning management systems, virtual and augmented reality, and AI-enhanced educational tools. Comprehending the manner in which educators embrace these innovations and their impact on pedagogical practices is crucial for ensuring that teacher education remains adaptable to technological advancements.

In conclusion, the study's results highlight the necessity for extensive and ongoing initiatives to enhance both technological-pedagogical competence and innovative thinking among mathematics educators. Stakeholders can contribute to ensuring that technology integration exceeds superficial adoption and significantly improves mathematics teaching and learning by implementing the above suggestions.

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APPENDIX A: DEMOGRAPHIC SURVEY

The demographic survey form used in the study is presented below.

DEMOGRAFİK BİLGİLER

Cinsiyetiniz nedir?

☐ Kadın ☐ Erkek

Yaşınız;

☐ 23 ve altı ☐ 23-33 ☐ 34-44 ☐ 45-55 ☐ 56 ve üzeri

Mezun olduğunuz programın düzeyi

☐ Ön lisans ☐ Lisans ☐ Yüksek Lisans ☐ Doktora

Kıdem yılınız;

☐ 1 yıldan az ☐ 1-5 yıl ☐ 6-10 yıl ☐ 11-15 yıl ☐ 16-20 yıl ☐ 21 yıl ve üzeri

Çalıştığınız okul türü;

☐ Devlet ☐ Özel

Daha önce temel bilgisayar kullanım kursu aldınız mı?

☐ Evet ☐ Hayır

Derste etkileşim tahta kullanım durumunuz;

☐ Her ders ☐ Bazen ☐ Hiç Kullanmam ☐ Sınıfta etkileşimli tahta yok

Figure A1. Demographic Survey Form Administered to Participants

APPENDIX B: TPACK SURVEY

The TPACK survey used to collect data from participants is presented below.

	Aşağıdaki ankette verilen teknopedagojik içerik bilgisi ile ilgili maddeleri inceleyip yeterlik düzeyinizi en uygun biçimde ifade eden <u>yalnız bir</u> seçeneği işaretleyiniz.	Kesinlikle Yapamam	Yapamam	Kısmen Yapabilirim	Yapabilirim	Rahatlıkla Yapabilirim
1.	Teknolojiden yararlanarak bir öğretim materyalini gereksinimlere (öğrenci, ortam, süre vb.) uygun olarak güncelleyebilme.	☐	☐	☐	☐	☐
2.	Öğretim süreci öncesinde öğrencilerin içeriğe dayalı gereksinimlerini belirlemek için teknolojiden yararlanabilme.	☐	☐	☐	☐	☐
3.	Öğretme-öğrenme sürecini zenginleştirmek için gereksinime uygun etkinlik geliştirmede teknolojiden yararlanabilme.	☐	☐	☐	☐	☐
4.	Öğretme-öğrenme sürecini teknolojik olanaklara uygun olarak planlayabilme.	☐	☐	☐	☐	☐
5.	Konu alanı öğretiminin niteliğini artırmak amacıyla kullanılacak teknolojilere yönelik gereksinim analizi yapabilme.	☐	☐	☐	☐	☐
6.	Bilgi ve İletişim Teknolojileri uygulamalarını kullanarak (eğitim yazılımı, sanal laboratuvar vb.) öğretim süresini optimum düzeye getirebilme.	☐	☐	☐	☐	☐
7.	Gereksinime uygun ölçme aracı geliştirmede teknolojiden yararlanabilme.	☐	☐	☐	☐	☐
8.	Konu içeriğinin etkili bir şekilde aktarılması için yöntem, teknik ve teknolojilerin özelliklerini değerlendirerek birbirleriyle uyumlu olanları seçebilme.	☐	☐	☐	☐	☐
9.	Etkili bir öğretme-öğrenme süreci için gereksinime uygun materyal tasarlamak amacıyla teknolojiden yararlanabilme.	☐	☐	☐	☐	☐
10.	Öğretme-öğrenme sürecinin gerçekleştirileceği ortamı teknoloji kullanımına uygun olarak düzenleyebilme.	☐	☐	☐	☐	☐
11.	Teknolojinin kullanıldığı öğretme-öğrenme süreçlerinde sınıf yönetimini sağlayabilme.	☐	☐	☐	☐	☐
12.	Öğrencilerin öğretim sürecine ilişkin geçerli bilgiye sahip olma durumlarını uygun teknolojileri kullanarak ölçebilme.	☐	☐	☐	☐	☐

Figure B1. Technological Pedagogical Content Knowledge (TPACK) Survey Items (Items 1–12)

The continuation of the TPACK survey items (13–24) is presented below.

13.	Bireysel farklılıklara uygun öğretim yaklaşım ve yöntemlerini teknoloji yardımıyla uygulayabilme.	☐	☐	☐	☐	☐
14.	Ödev, proje, staj gibi eğitsel etkinlikleri yürütmede teknolojiden yararlanabilme.	☐	☐	☐	☐	☐
15.	Öğretim sürecinde teknoloji destekli iletişim ortamlarından (blog, forum, sohbet, e-posta vb.) yararlanabilme.	☐	☐	☐	☐	☐
16.	Öğrencilerin konu alanına ilişkin başarı durumlarını değerlendirmede teknolojiyi kullanabilme.	☐	☐	☐	☐	☐
17.	Öğretim sürecinde etik kurallara uygun teknoloji kullanımında öğrenciye model olabilme.	☐	☐	☐	☐	☐
18.	Öğrencilerin teknolojiye dayalı ürün (sunu, oyun, film vb.) oluşturma sürecine rehberlik yapabilme.	☐	☐	☐	☐	☐
19.	Öğretme-öğrenme sürecine destek amaçlı güncel teknolojik yeniliklerden (facebook, blog, twitter, podcasting vb.) yararlanabilme.	☐	☐	☐	☐	☐
20.	Öğretim gerçekleştirilecek konu alanı bilgi ve becerilerini güncellemede teknolojiden yararlanabilme.	☐	☐	☐	☐	☐
21.	Öğretim sürecinde kullanılan teknoloji bilgisini güncel tutabilme.	☐	☐	☐	☐	☐
22.	Öğretim sürecine ilişkin bilginin güncel tutulmasında teknolojiden yararlanabilme.	☐	☐	☐	☐	☐
23.	Eğitim ortamlarında teknolojinin erişimi konusunda atik davranabilme.	☐	☐	☐	☐	☐
24.	Konu alanı öğretiminde yararlanılacak özel/mahrem bilgileri teknoloji aracılığıyla edinmede (ses kaydı, video, kayıt, döküman vb.) ve kullanmada etik kurallara uyma.	☐	☐	☐	☐	☐

Figure B2. Technological Pedagogical Content Knowledge (TPACK) Survey Items (Items 13–24)

The continuation of the TPACK survey items (13–24) is presented below.

TEKNOPEDAGOJİK İÇERİK BİLGİSİ YETERLİKLERİ ÖLÇEĞİ

		Kesinlikle Yapamam	Yapamam	Kısmen Yapabilirim	Yapabilirim	Rahatlıkla Yapabilirim
25.	Öğretme-öğrenme sürecinin her aşamasında teknolojiiden fikri mülkiyet (telif, lisans vb.) konularına uyarak yararlanabilme.	☐	☐	☐	☐	☐
26.	Teknoloji tabanlı öğretim ortamlarında (WebCT, Moodle vb.) sürecin her aşamasında öğretmenlik mesleği etik kurallarına uyma.	☐	☐	☐	☐	☐
27.	Öğretme-öğrenme sürecinde öğrencileri geçerli ve güvenilir dijital kaynaklara yönlendirerek doğru bilgiye ulaşmalarına rehberlik edebilme.	☐	☐	☐	☐	☐
28.	Eğitim ortamlarında teknolojinin sağlıklı kullanımı konusunda etik davranabilme.	☐	☐	☐	☐	☐
29.	Teknoloji tabanlı öğretim ortamlarında (WebCT, Moodle vb.) karşılaşılabilecek problemleri çözebilme.	☐	☐	☐	☐	☐
30.	Öğretme-öğrenme sürecinin her aşamasında teknolojiiden yararlanırken ortaya çıkabilecek sorunları çözebilme.	☐	☐	☐	☐	☐
31.	Konu alanıyla ilgili karşılaşılan problemlere (içeriğin yapılandırılması, güncellenmesi, gerçek yaşamla ilişkilendirilmesi vb.) yönelik çözüm üretmede teknolojiyi kullanabilme.	☐	☐	☐	☐	☐
32.	Alanıyla ilgili teknolojik yeniliklerin öğretim sürecinde kullanımının yayılmasına liderlik edebilme.	☐	☐	☐	☐	☐
33.	İçeriğin aktarımı sürecinde karşılaşılan problemlerin çözümünü için teknolojiiden yararlanma konusunda disiplinlerarası işbirliği yapabilme.	☐	☐	☐	☐	☐

Figure B3. Technological Pedagogical Content Knowledge (TPACK) Survey Items (Items 25–33)

APPENDIX C: INNOVATIVENESS SURVEY

The innovativeness survey used to measure participants' individual innovativeness is presented below.

BİREYSEL YENİLİKÇİLİK ÖLÇEĞİ

	Aşağıdaki ankette verilen bireysel yenilikçilik ile ilgili maddeleri inceleyip yeterlik düzeyinizi en uygun biçimde ifade eden <u>yalnız bir</u> seçeneği işaretleyiniz.	Kesinlikle Katılmıyorum	Katılmıyorum	Kısmen Katılmıyorum	Katılıyorum	Kesinlikle Katılıyorum
1.	Arkadaşlarım öneri veya bilgi almak için sık sık bana başvururlar.	☐	☐	☐	☐	☐
2.	Yeni fikirleri denemekten hoşlanırım.	☐	☐	☐	☐	☐
3.	Bir şeyi yapmanın yeni yollarını ararım.	☐	☐	☐	☐	☐
4.	Genellikle yeni fikirleri kabullenmekte temkinliyimdir.	☐	☐	☐	☐	☐
5.	Bir sorunu çözerken yanıt açık olmadığı zaman çözüm için çoğu kez yeni yöntemler geliştiririm.	☐	☐	☐	☐	☐
6.	Yeni icatlara ve yeni düşünce tarzlarına karşı şüpheciyimdir.	☐	☐	☐	☐	☐
7.	Çevremdeki insanların büyük bir çoğunluğunun kabul ettiğini görene kadar yeni fikirlere pek itibar etmem.	☐	☐	☐	☐	☐
8.	Arkadaş grubum içinde etkili bir birey olduğumu düşünürüm.	☐	☐	☐	☐	☐
9.	Düşüncelerimde ve davranışlarımda kendimi yaratıcı ve özgün görürüm.	☐	☐	☐	☐	☐
10.	Genellikle arkadaş grubum içinde yeni bir şeyi kabul eden son kişilerden biri olduğumu düşünüyorum.	☐	☐	☐	☐	☐
11.	Yaratıcı bir kişiliğe sahibimdir.	☐	☐	☐	☐	☐
12.	Ait olduğum grubun liderlikle ilgili sorumluluklarını almaktan hoşlanırım.	☐	☐	☐	☐	☐

Figure C1. Individual Innovativeness Scale Survey Items (Items 1–12)

The continuation of the innovativeness survey items (13–20) is presented below.

		Kesinlikle Katılmıyorum	Katılmıyorum	Kısmen Katılmıyorum	Katılıyorum	Kesinlikle Katılıyorum
13.	Çevremdeki bireylerde işe yaradığını görene kadar bir işi yapmanın yeni yollarını kabullenmekte isteksiz davranırım.	☐	☐	☐	☐	☐
14.	Düşüncelerimde ve davranışlarımda özgün olmayı heyecan verici bulurum.	☐	☐	☐	☐	☐
15.	Eski usul yaşam tarzının ve işleri eski yöntemlerle yapmanın en iyisi olduğunu düşünürüm.	☐	☐	☐	☐	☐
16.	Belirsizlikler ve çözülmemiş problemler beni güdüler.	☐	☐	☐	☐	☐
17.	Yenilikleri dikkate almadan önce diğer insanların o yeniliği kullandığını görmeliyim.	☐	☐	☐	☐	☐
18.	Yeni fikirlere açığımdır.	☐	☐	☐	☐	☐
19.	Cevabı belirsiz sorular beni heyecanlandırır.	☐	☐	☐	☐	☐
20.	Yeni fikirlere karşı çoğunlukla şüpheciyimdir.	☐	☐	☐	☐	☐

Figure C2. Individual Innovativeness Scale Survey Items (Items 13–20)

APPENDIX D: INTERVIEW IN ENGLISH

The interview questions in English prepared for data collection are presented below.

INTERVIEW

Full Name _____

Guidelines

This interview aims to understand the relationship between individuals' technological knowledge and their level of innovativeness. The questions in the interview focus on topics such as technology budget, technology ownership, update time for technological devices, the number of utilized internet applications, and internet using habits. Participants are expected to provide precise and honest responses; there are no right or wrong answers. The collected data will be recorded both in audio and written form and will be used solely for research purposes while being protected under confidentiality principles.

1. Technology Budget

- How does your institution allocate its budget for technology in education?
- Is the current technology budget sufficient for effectively integrating technology into teaching? (TK, TPK)
- What challenges do you face regarding budget constraints in acquiring or upgrading technological tools?
- How does budget availability impact your ability to align technology with pedagogy and content? (TPACK)

2. Technology Ownership

- What technological devices do you personally own and use for educational purposes?
- Does having personal access to technology enhance your ability to integrate it into your teaching? Why or why not? (TK, TPK)
- How does your institution support teachers' technology ownership (e.g., providing laptops, tablets, or software access)?
- In your experience, do students' technology ownership levels affect their ability to engage with content effectively? How do you address this in your teaching? (TPK, TPACK)

Thank you for taking the time to complete the interview.
Your feedback will help me improve my thesis.

Figure D1. Interview Form in English (Guidelines and Items 1–2)

The continuation of the interview questions in English is presented below.

The image shows a digital interview form with a blue header and footer. The header contains the word 'INTERVIEW' in white capital letters. The form is divided into three sections, each with a title in a light blue box and a list of questions in a white box. The questions are numbered 3, 4, and 5. The footer contains a thank you message in white text on a blue background.

INTERVIEW

3. Update Time for Technological Devices

- How often do you or your institution update technological devices (computers, projectors, interactive boards, etc.)?
- What challenges do you face when outdated devices hinder your ability to integrate technology into teaching? (TK)
- How do you decide when to update your personal or school-provided technological tools to support student learning? (TPK, TPACK)
- Do you believe frequent updates improve your ability to align technology with pedagogical strategies? Why or why not? (TPACK)

4. Number of Utilized Internet Applications

- What Internet applications do you use in your teaching (GeoGebra, Codap, Desmos)? (TK, TPK)
- How do these applications support student engagement and conceptual understanding in your subject? (TPACK)
- What challenges do you face in accessing or effectively using these applications that are aligned with your teaching strategies? (TPK)
- How do you determine which Internet applications best align with your content and pedagogy? (TPACK)

5. Internet Using Habits

- How frequently do you use the Internet for educational purposes? (TK)
- How do you use the Internet to enhance teaching strategies and student learning? (TPK, TPACK)
- Do you feel comfortable navigating and utilizing online educational resources? Why or why not? (TK, TPK)
- What are the main obstacles you face in using the Internet effectively for teaching, and how do you address them? (TPACK)

Thank you for taking the time to complete our customer satisfaction survey.
Your feedback will help us improve our product/service.

Figure D2. Interview Form in English (Items 3–5, continued)

APPENDIX E: INTERVIEW IN TURKISH

The interview questions in Turkish prepared for data collection are presented below.

MÜLAKAT

Ad Soyad _____

YÖNERGE

Bu mülakat, bireylerin teknoloji kullanım alışkanlıkları ile yenilikçilik düzeyleri arasındaki ilişkiyi anlamayı amaçlamaktadır. Mülakatta yer alan sorular, teknolojiye yapılan harcamalar, sahip olunan cihazlar, teknolojik güncellemelerin sıklığı, kullanılan Internet uygulamalarının sayısı ve Internet kullanım alışkanlıkları gibi konulara odaklanmaktadır. Mülakat sırasında açık ve dürüst cevaplar vermeniz beklenmektedir; doğru ya da yanlış cevap yoktur. Elde edilen veriler sesli ve yazılı olarak kaydedilip yalnızca araştırma kapsamında değerlendirilecek olup, gizlilik prensipleri çerçevesinde korunacaktır.

1. Teknoloji Bütçesi

- Kurumunuz eğitimde teknoloji için bütçesini nasıl tahsis ediyor?
- Mevcut teknoloji bütçesi, teknolojiyi öğretme etkili bir şekilde entegre etmek için yeterli mi? (TK, TPK)
- Teknolojik araçları edinme veya yükseltme konusunda bütçe kısıtlamalarıyla ilgili hangi zorluklarla karşılaşyorsunuz?
- Bütçe imkânlarının, teknolojiyi pedagojik yöntemler ve içerikle uyumlu hale getirme yeteneğinizi nasıl etkilediğini düşünüyorsunuz? (TPACK)

2. Teknoloji Sahipliği

- Eğitim amaçlı kişisel olarak sahip olduğunuz ve kullandığınız teknolojik cihazlar nelerdir?
- Kişisel olarak teknolojiye erişiminizin olması, onu öğretiminize entegre etme yeteneğinizi artırıyor mu? Neden veya neden değil? (TK, TPK)
- Kurumunuz öğretmenlerin teknoloji sahipliğini nasıl destekliyor? (Örneğin, dizüstü bilgisayar, tablet veya yazılım erişimi sağlıyor mu?)
- Deneyiminize göre, öğrencilerin teknolojiye sahip olma düzeyleri, içeriğe etkili bir şekilde katılımlarını etkiliyor mu? Bunu öğretiminizde nasıl ele alıyorsunuz? (TPK, TPACK)

Figure E1. Interview Form in Turkish (Guidelines and Items 1–2)

The continuation of the interview questions in Turkish is presented below.

INTERVIEW
3. Teknolojik Cihazların Güncellenme Sıklığı - Siz veya kurumunuz teknolojik cihazları (bilgisayarlar, projektörler, etkileşimli tahtalar vb.) ne sıklıkla güncelliyorsunuz? - Güncellenmemiş, eski cihazların teknolojiyi öğretime entegre etmenizi zorlaştırdığı durumlarda karşılaştığınız zorluklar nelerdir? (TK) - Öğrenci öğrenimini desteklemek için kişisel veya okul tarafından sağlanan teknolojik araçları ne zaman güncelleyeceğinize nasıl karar veriyorsunuz? (TPK, TPACK) - Sık güncellemelerin teknolojiyi pedagojik stratejilerle uyumlu hale getirme yeteneğinizi artırdığına inanıyor musunuz? Neden veya neden değil? (TPACK)
4. Kullanılan İnternet Uygulamaları Sayısı - Öğretiminizde hangi internet uygulamalarını kullanıyorsunuz? (Örneğin, GeoGebra, Codap, Desmos)(TK, TPK) - Bu uygulamalar, öğrencilerin derse katılımını ve kavramsal anlamalarını nasıl destekliyor? (TPACK) - Öğretim stratejilerinizle uyumlu olan bu uygulamalara erişimde veya etkili kullanımda karşılaştığınız zorluklar nelerdir? (TPK) - Hangi internet uygulamalarının içeriğiniz ve pedagojinizle en iyi şekilde uyum sağladığını nasıl belirliyorsunuz? (TPACK)
5. İnternet Kullanım Alışkanlıkları - Eğitsel amaçlar için interneti ne sıklıkla kullanıyorsunuz? (TK) - Öğretim stratejilerini geliştirmek ve öğrenci öğrenimini desteklemek için interneti nasıl kullanıyorsunuz? (TPK, TPACK) - Çevrimiçi eğitim kaynaklarını kullanma ve yönlendirme konusunda kendinizi rahat hissediyor musunuz? Neden veya neden değil? (TK, TPK) - İnterneti öğretimde etkili bir şekilde kullanırken karşılaştığınız en büyük engeller nelerdir ve bunları nasıl aşıyorsunuz? (TPACK)

Figure E2. Interview Form in Turkish (Items 3–5, continued)

APPENDIX F: ETİK KURULU İZNİ

The ethical committee approval document granted by Boğaziçi University is presented below.



T.C.
BOĞAZİÇİ ÜNİVERSİTESİ REKTÖRLÜĞÜ
Sosyal ve Beşeri Bilimler İnsan Araştırmaları Etik Kurulu (Sbınarek)



Sayı : E-84391427-050.04-239938

03.07.2025

Konu : Kayıt 2024-46T Nolu Başvurunuzla İlişkin Etik
Kurul Onay Kararı (2025-05)

Sayın Dr. Öğr. Üyesi Kemal AKOĞLU

Tez danışmanlığımı yürütmek olduğunuz öğrenciniz Ayşegül Yoldaş'ın "Hizmetiçi Ortaokul Matematik Öğretmenlerinin Teknolojik Pedagojik Alan Bilgisi (TPAB) Düzeyleri ile Yenilikçilik Özellikleri Arasındaki İlişki" başlıklı projesi ile Boğaziçi Üniversitesi Sosyal ve Beşeri Bilimler İnsan Araştırmaları Etik Kurulu'na (SBİNAREK) yaptığımız, 2025-46T kayıt numaralı başvuru 16.06.2025 tarihli ve 2025/05 sayılı kurul toplantısında, incelenmiş olup projenize etik onay verilmesi uygun bulunmuştur.

Bu karar, tüm kurul üyelerinin çevrim içi katılımıyla gerçekleştirilen toplantıda oy birliği ile alınmıştır. Onay mektubu, tüm üyeler adına Kurul Başkanı tarafından e-imzalanmıştır.

Bilgilerinizi rica ederiz.

Saygılarımızla,

Dr. Öğr. Üyesi İşıl ERDUYAN
Kurul Başkanı

Bu belge, güvenli elektronik imza ile imzalanmıştır.

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Figure F1. Ethics Committee Approval Letter for the Study