TUĞBA ÖZCAN

2015

THE MATHEMATICAL AND COMMUNICATIVE DISCOURSE IN A MULTICULTURAL CONTENT BASED CLASSROOM OF AN INTERNATIONAL SCHOOL: AN ETHNOGRAPHIC STUDY

A MASTER'S THESIS

BY

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THE PROGRAM OF CURRICULUM AND INSTRUCTION
İHSAN DOĞRAMACI BİLKENT UNIVERSITY
ANKARA

MAY 2015

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The Graduate School of Education

of

İhsan Doğramacı Bilkent University

by

Tuğba Özcan

In Partial Fulfilment of the Requirements for the Degree of

Master of Arts

in

The Program of Curriculum and Instruction
İhsan Doğramacı Bilkent University
Ankara

May 2015

İHSAN DOĞRAMACI BİLKENT UNIVERSITY

GRADUATE SCHOOL OF EDUCATION

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May 2015

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Arts in Curriculum and Instruction.

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ABSTRACT

THE MATHEMATICAL AND COMMUNICATIVE DISCOURSE IN A MULTICULTURAL CONTENT BASED CLASSROOM OF AN INTERNATIONAL SCHOOL: AN ETHNOGRAPHIC STUDY

Tuğba Özcan

M.A., Program of Curriculum and Instruction

Supervisor: Asst. Prof. Dr. Deniz Ortaçtepe

May 2015

The purpose of this ethnographic study was to investigate the culture of a content-based English/Mathematics classroom in terms of mathematical and communicative discourse. The participants of this study were 21 multicultural secondary grade students and an international mathematics teacher in a content-based classroom of an international school in Turkey. The main data instrument was the researcher as a participant observer. The data were the audio-recordings gathered through 17 separate secondary grade lessons consisted of 540 minutes course-time. In the data analysis, two different methods were used: qualitative method to investigate the characteristics of the mathematical discourse and descriptive method to analyze the communicative discourse using a research-based scheme.

The results indicated that in this multicultural content-based classroom, mathematical discourse was productive in terms of encouraging students to use the language of mathematics; strategies, solution methods and different perspectives; mathematical reasoning and mathematical justification; and connection between mathematical ideas/concepts and extension in mathematical thinking. As a result, the students in this classroom did and learned mathematics by participating in mathematical discourse. The teacher-students interactions were effective in terms of teaching mathematics but it needed to improve for developing learner's English. As this was a multicultural content-based classroom where English was the only medium of instruction, it carried features of mathematical discourse. Yet, in terms of communication, the teacher tended to ask questions to which she already knew the answers, and that restricted the variety of language forms that students could produce. To conclude, in a multicultural content-based classroom, mathematics instruction should aim to encourage English learner students to participate in communicative discourse more because they are not only learning mathematics but also English.

Key Words: Content-based instruction, mathematical discourse, communicative discourse, content-based English/Mathematics classroom, international school, multicultural classrooms.

ÖZET

ULUSLARARASI BİR OKULUN İÇERİK TABANLI BİR SINIFINDA MATEMATİKSEL VE İLETİŞİMSEL SÖYLEMLER: BİR ETNOGRAFİK ÇALIŞMA

Tuğba Özcan

Yüksek Lisans, Eğitim Programları ve Öğretim

Tez Yöneticisi: Yard. Doç. Dr. Deniz Ortaçtepe

Mayıs 2015

Bu etnografik çalışmanın amacı matematiksel ve iletişimsel söylemler açısından içerik tabanlı İngilizce/Matematik sınıf kültürünü incelemektir. Bu çalışmanın katılımcıları Türkiye'de uluslararası bir okulda ve eğitim dilinin İngilizce olduğu bir sınıfta matematik öğrenen 21-ortaokul öğrencisi ve uluslararası bir matematik öğretmeninden oluşmaktadır. Ana veri aracı olarak ders söylemlerinin ses kayıtları kullanılmıştır. Veri, iki farklı analiz yöntemi kullanılarak analiz edilmiştir: matematiksel söylemleri araştırmak için nitel yöntem kullanılırken; iletişimsel söylemler araştırma tabanlı bir şema kullanılarak betimsel analiz edilmiştir.

Bu içerik tabanlı sınıfta, matematiksel söylemin: matematik dilini kullanma; stratejileri, çözüm yöntemleri ve farklı bakış açılarını kullanma; matematiksel akıl yürütme ve matematiksel gerekçe; matematiksel fikirler/kavramlar arasında bağlantı kurma ve matematiksel düşünmeyi geliştirme yönlerinden yararlı olduğu görülmüştür. Sonuç olarak, bu sınıfta öğrencilerin matematiksel söyleme katılarak matematik öğrendikleri ve matematik yaptıkları ortaya çıkmıştır. Öğretmen-öğrenci

etkileşimi matematik öğretimi açısından iyi sonuçlar çıkarırken; bu etkileşimin öğrencilerin İngilizcelerini geliştirmek için yeterince iyi olmadığı görülmüştür. Bir içerik tabanlı sınıfta, matematik eğitimi sadece matematik öğretmeyi değil, aynı zamanda iletişimsel söylemleri kullanarak öğrencilerin İngilizcelerini geliştirmeyi amaçlamalıdır.

Anahtar Kelimeler: İçerik tabanlı öğretim, matematiksel söylemler, iletişimsel söylemler, içerik tabanlı sınıflar, uluslararası okullar, çok kültürlü sınıflar.

ACKNOWLEDGEMENTS

I would like to offer my sincerest appreciation to Prof. Dr. Ali Doğramacı and Prof. Dr. Margaret K. Sands, and to all members of the İhsan Doğramacı Bilkent University Graduate School of Education community for supporting me throughout the program.

I would like to express profound gratitude to my supervisor, Asst. Prof. Dr. Deniz Ortaçtepe, for her invaluable support, substantial suggestions and endless patience. Her moral support and continuous guidance enabled me to complete my thesis successfully on time. I am extremely grateful for her help and encouragement throughout the process of writing my thesis.

I would also like to acknowledge and offer my sincere thanks to members of my committee, Prof. Dr. Kimberly Trimble and Assoc. Prof. Dr. M. Sencer Çorlu for their comments about my thesis. I am thankful to Dr. Çorlu also for his useful suggestions and support throughout writing my thesis. He shared with me his experiences and his deep knowledge about ethnographic research and mathematical discourse.

Finally, my sincere gratitude goes to my family and my friends for their love, patience and support throughout writing my thesis. I am also grateful my uncle, Mahmut Kalkan for all his help. I dedicate this thesis to the students who participated in this study.

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CHAPTER 1: INTRODUCTION

Introduction

The main purpose of any language is communication. This is because people use language, which is a system of signs, symbols or gestures, as a tool to communicate with each other. However, according to Vygotsky (1978), language is not only a tool of communication but also a tool for reflection and thinking so that it plays a dialectical role in an individual's cognitive development (Jäppinen, 2005). There are many empirical studies supporting the views of Vygotsky (e.g., Brendefur & Frykholm, 2000; Moschkovich, 1998; Peressini & Knuth, 2000). Yet, communication varies according to the language used because each language makes sense in respect to how and in which content it is used.

English as an international language has a significant role on people's lives for knowledge acquisition and communication. Moreover, English prepares future generation with a language which enables them to reach new developments and advances in science and technology so that they can meet the challenges resulting from globalization (Lim & Presmerg, 2010). English supports students' achievements in mathematics in bi/multilingual classes (Davis, Bishop, & Seah, 2013). According to Crandall (1995), science learning can support and improve the learning of English. As a consequence, language plays a significant role in teaching and learning mathematics in terms of knowledge acquisition and communication. Mathematics as being the language of science can ensure this development.

As Schleppegrell, Achugar, and Oteiza (2004) state, no language can be taught in isolation from content, and similarly, no disciplinary knowledge can be taught in isolation from language. Thus, the purpose of this study is to examine the culture of a content-based classroom by focusing on the mathematical and communicative discourse in this multicultural classroom.

Background

Content based instruction

Content-based instruction (CBI) is an instruction method which integrates languages into the content (Crandal 1987; Schleppegrell, Achugar, & Oteíza, 2004; Reilly, 1988). Content-based instruction was first conducted effectively in Canada French/English through an immersion program, in U.S.A. through a Hispanic/English immersion program, in New Zealand through a Mori/English immersion program and University of Ottawa's sheltered program (Cummins, 1995, 2001; Genesee, 1987; Grabe & Stoller, 1997; Hartiala, 2000; Kasper, 2000; Marsh & Hartiala, 2001; Met, 1991; Swain & Johnson, 1997). It also became a part of elementary and secondary school English-as-Second-Language (ESL) instruction programs which enable non-native English speaker students to acquire academic proficiency in English (Ovando & Collier, 1998; Wang, 2013).

Content-based instruction enables students "to learn a new language by *using* that language, from the very first class, as a real means of communication" and "to become independent learners and continue the learning process beyond the classroom" (Stryker & Leaver, 1997, p. 3). The most successful way to acquire a language is *communicative language learning*, which is to learn the target language for communication purposes (Brumfit & Johnson, 1979; De Graaff, Jan Koopman, Anikina, & Westhoff, 2007; Ortaçtepe & Akyel, 2015). In this manner, CBI serves this approach of communicative language teaching (Crandall, 1992) because in content-based classrooms, students can effectively learn both language and subject matter knowledge, "by receiving content input in the target language" (Dueñas, 2003, p.1). With CBI, students can learn new concepts through meaningful content while developing their language skills (Grabe & Stoller, 1997; Heo, 2006).

Moreover, content-based approaches enhance students' motivation and acquisition of language proficiency by broadening their cross-cultural knowledge and by making the learning process more enjoyable and fulfilling. Besides, experiences in multicultural classes indicate that students who are taught in a well-organized content-based program are more likely to engage in meaningful while they are learning language so that they become autonomous, and lifelong learners (Lantolf & Pavlenko, 1995; Stryker & Leaver, 1997).

Content-based instruction can be efficient because students learn the subjects such as science, history, or mathematics using the target language. The target language can be simultaneously learned in the lessons so that the amount of time that students spend for studying the new language can decrease. For example, the students can learn the target language while they are learning mathematics (Lightbown, 2014). Content-based instruction can be motivating because learning the content and the target language may occur simultaneously. Therefore, CBI can promote advanced proficiency by developing varied and sophisticated vocabulary in a way that prepares students for further academic, personal or work-related language use outside the classroom (Lightbown, 2014).

Content based instruction in mathematics

The arguments of teaching English as a second language through mathematics started early in the 1980s in the United States (Cuevas, 1984). This issue then became more popular around the world with the help of researchers who sought ways to effectively teach English to second language learners (Campbell, Davis, & Adams, 2007). Content-based instruction in mathematics focuses not only on the learning of a second language, but also on using that language as a medium to learn mathematics, and using mathematics as a means for developing second-language skills (Mason & Barba, 1992; Wang, 2013).

Mathematical discourse

Although language is a tool of communication (Vygotsky, 1978), discourse has a broader meaning in which the language is used (Gutiérrez, Sengupta-lrving, & Dieckmann, 2010; Sfard, 2007). As discourse is more than a language (Gee, 2014), mathematical discourse is much more than the use of mathematical language (Moschokovich, 1998) which involves multiple modes, representations (gestures, objects, drawings, tables, graphs, symbols, etc.), diverse perspectives, reasoning, revoicing and making sense of mathematical ideas as well as providing justification to mathematical arguments (Chapin, O'Connor, & Anderson, 2009; Moschokovich, 2006; Molle, Sato, Boals, & Hedgspeth, 2015). Mathematical discourse includes "the ways of representing, thinking, talking, agreeing and disagreeing" about mathematics (National Council of Teaching Mathematics, 1991, p. 34).

Mathematical discourse is also an instructional strategy which plays a significant role in nurturing students' development of conceptual mathematical ideas and in-depth knowledge (Brendefur & Frykholm, 2000; Peressini & Knuth, 2000; Silver & Smith, 1996). Strategically structured mathematical discourse enables students to focus on meaning making and reasoning while it allows teachers to evaluate students' comprehension and to foster conceptual understanding and mathematical thinking (Boaler & Greeno, 2000; Kazemi, 1998; Piccolo, Harbaugh, Carter, Capraro & Capraro, 2008; Simon & Blume, 1996; White, 2003).

Problem

Discourse as an instructional strategy in content-based classrooms has importance for a student learning mathematics and English simultaneously. Researchers, teacher educators and teachers from all around the world have discovered that they can help students to become autonomous learners by encouraging them to participate in mathematical and commutative discourse in content-based classrooms. Although the issue of whether secondary level students efficiently can participate in mathematical discourse in mathematics lessons is highly debatable in education, studies have failed to reach a conclusive decision about the culture of a multicultural content-based classroom in terms of mathematical and communicative discourse in these classrooms. Furthermore, even though there are several multicultural classrooms at international schools applying CBI in Turkey, almost no research has been conducted on the issue of mathematical and communicative discourses in a multicultural content-based classroom. Therefore, in order to address these problems further research is needed.

Purpose

The main purpose of this ethnographic study is to investigate the culture of a content-based English/Mathematics classroom. Specifically, kinds of mathematical discourse in mathematics teaching and the communicative discourse will be explored in a multicultural English/Mathematics classroom of an international school in Turkey.

Research question

This study addresses the following question:

How can the culture of an English/Mathematics classroom be described in terms of

(1) mathematical discourse?

(2) communicative discourse?

Significance

The current research in mathematics education indicates that language plays a significant role in teaching and learning mathematics in terms of knowledge acquisition and communication (Davis, Bishop, & Seah, 2013). Additionally, the bilingual/multilingual students have difficulties to learn mathematics since they are not fluent enough in their second language when it is the medium of instruction (Lim & Presmeg, 2010). In addition, some studies reveal that students' conversations enhance their subject and language learning (Boaler & Greeno, 2000; Kazemi, 1998; Simon & Blume, 1996). In this framework, the productive classroom discourse not only helps these students in terms of the improvement of their mathematical thinking and their language learning but also teachers about teaching mathematics (Blanton, Berenson, & Norwood, 2001; Chapin, O'Connor, & Anderson, 2009).

However, the findings of recent research provide a limited view of doing mathematics in a content-based classroom and do not address the growing emphasis on mathematical and communicative discourse in multicultural content-based classrooms. It is hoped that this study generates an interest about the culture of a content-based instruction regarding mathematical and communicative discourse. Its purpose also is to raise a number of questions and observations about the current view of mathematical and communicative discourse in mathematics education and in content-based instruction literature.

Therefore, this study is hoped to contribute to the non-native speakers who are learning mathematics in a content-based English-mathematics classroom, by enabling them to use English within the context of mathematics more effectively while doing mathematics. Furthermore, this study can be a guiding tool for not only teachers and researchers working in this field as a means of self-analysis, but also for teacher educators in terms of helping student-teachers to develop themselves in terms of effective teaching techniques. For teachers and student-teachers, this study also establishes that mathematical and communicative discourse can act as a new model for conducting mathematics lessons to enrich students' participation in mathematical and communicative discourse.

CHAPTER 2: LITERATURE REVIEW

Introduction

As the importance of discourse for students, learning mathematics and English, continues to grow in many countries, the issue of mathematical or communicative discourse in content-based classrooms is widely debated in the field of education (Brahier, 2010; Gee, 2007; Moschkovich, 1999; 2007; National Council of Teaching Mathematics, 1991, 1996, 2007; O'Connor & Michaels, 1993; Sfard, 2007). However, further research is required about the culture of a multicultural content-based classroom in terms of mathematical and communicative discourses in this classroom. Hence, this chapter discusses the literature on content-based instruction as well as mathematical and communicative discourse in content-based classrooms and international education.

Content based instruction

Definition of content-based instruction

Content-based instruction (CBI) is "more a philosophy than a methodology" which is "a truly holistic and global approach to foreign language education" (Stryker & Leaver, 1997, p. 3). Content-based instruction aims to enable students "to learn a new language by using that language, from the very first class, as a real means of communication" and "to become independent learners and continue with the learning process beyond the classroom" (Stryker & Leaver, 1997, p. 3). Content-based instruction raises students' motivation and acquisition of language proficiency by broadening their cross-cultural knowledge and by making the language learning more enjoyable and fulfilling. Moreover, experiences in foreign classes indicate that students who are taught a well-organized content-based program are more likely to engage in meaningful communication while they are learning language so that they become autonomous, lifelong learners (Lantolf & Pavlenko, 1995; Stryker & Leaver, 1997). Content-based instruction has been defined as an effective and realistic teaching method in terms of combining language and content learning (Kranke, 1987). Moreover, with CBI, students can learn new concepts through meaningful content while they are developing their language skills (Heo, 2006). Content-based instruction can be efficient because students learn the subjects simultaneously such as science, history, or mathematics and the language in the lessons so that the amount of time that students spend directly learning the new language can decrease. For example, "the students are learning language as they learn mathematics, with an emphasis on language as the vehicle for subject-matter learning" (Lightbown, 2014, p. 10). Content-based instruction can be motivating because learning the content and language at the same time can diminish the failure to understand the academic content. Content-based instruction can "promote advanced proficiency" (p. 10) in terms of the occasions of varied and sophisticated vocabulary so that it prepares the students to a further academic, personal or work-related language usage outside the classroom (Lightbown, 2014).

History of content based instruction

During the 1960s in the former Soviet Union and Canada, contemporary content-based instruction (CBI) gained importance through the experiments conducted at special secondary foreign language schools where all subjects were taught in the foreign language. However, although there was a rising demand, in the former Soviet Union, these programs disappeared by the mid-1980s due to the lack of qualified teachers (Stryker & Leaver, 1997). In Canada, in the early 1960s, CBI was designed to teach French to English-speaking K-12 students and served as the methodological cornerstone of second language *immersion* programs which have gained success, reputation, and ultimately publicity (Cummins, 1981; Stryker & Leaver, 1997). By the mid-1990s, in the United States, similar programs adopted the Canadian model, most of which served Spanish-English bilingual communities, for example, the Culver City Experiment (Cohen & Swain, 1976). The use of content-based sheltered English lessons in these programs indicated that the students, especially those who entered K-12 classes with little or no English proficiency, were successful in these lessons (Stryker & Leaver, 1997).

Several theories and models supported CBI in English as a second language (ESL) and in bilingual settings. Brinton, Snow, and Wesche (1989) describe three models for CBI at multiple levels. They are theme-based courses, sheltered instruction and adjunct instruction in which English as a Second Language (ESL) and English as a Foreign Language (EFL) are taught. Chamot and O' Malley (1986) identified three goals for content-based instruction which are answering the academic needs of elementary and secondary English language learners, being a bridge between ESL and mainstream education, and setting up an instruction based model of cognitive learning. Furthermore, according to Nunan (1989), task-based activities, combined with CBI in a curriculum, are useful for students to draw their attention to meaning rather than form (which is vocabulary or grammar). Moreover, Nunan (1989) also recommends the use of three types of tasks which are “information gaps (e.g., find out what is missing in two pictures), reasoning gaps (e.g., find what is wrong with a picture), and opinion gaps (e.g., rate our favorites and tell why)" (p.86).

Additionally, task-based instruction when combined with CBI in ESL and EFL programs is helpful for students who study in pairs to discuss the meaning when exchanging information or solving problems (Stryker & Leaver, 1997). Content-based instruction gained a common attention in EFL settings, as well. For instance, Johnson-Laird (1991) described CBI courses at Temple University's campus in Japan as a useful instruction for Japanese students to prepare them for the university's academic program in English.

Theories and models of content based instruction

Crandall and Tucker (1990) suggested that CBI programs that included the combination of three basic approaches which are integrated language/content instruction by a language teacher, integrated instruction taught by a content teacher, and parallel courses. An example of this program was designed for students who try to enter universities in the United States which was developed by the Center for Applied Linguistics in Honduras. In this program, bilingual teachers teach mathematics and science courses by beginning with Spanish and then integrating progressively more English and finally finishing with all-English instruction. Simultaneously, English instructors integrate more content into their courses by using sheltered content and parallel courses in Spanish (Stryker & Leaver, 1997). The most common variations in foreign language models, implemented by increasing numbers of second and foreign language educators worldwide are popularized by Brinton, Snow, and Wesche (1989) and by Crandall (1993). Crandall (1992) stated eight content-area learning models, which are content-based language instruction, sheltered subject, matter teaching, theme-based, sheltered instruction, and language across the curriculum, adjunct model, and cognitive academic language learning approach (CALLA). Among these approaches, the most common variations in foreign language models are *theme-based courses* (TB), *adjunct/linked courses* (AL), *sheltered subject matter instruction* (SSM), and *second language medium courses* (SLM) (Brinton, Snow, & Wesche, 1989; Crandall, 1993; Snow, 1998; Oxford, 2001).

Content-based language instruction (CBLI) is an approach in which immigrant or minority-language students are taught both a new language and academic subjects at the same time. It is based on three initial and two later theoretical models. These are Cummin's (1981) two-tiered skill model, Krashen's (1989) comprehensible input hypothesis and cognitive learning theory, Snow and Brinton's (1997) model of CBI methods in contextualized language curricula and Richard and Roger's (2001) theory of authentic, contextualized, linguistically-challenging materials interaction in communicative and academic context.

Content-based instruction can be applied by using traditional teaching methods (e.g., grammar and vocabulary based instruction) and contemporary approaches (e.g., communicative language teaching) (Crandal, 1987). Moreover, in foreign language teaching, communicative language teaching (CLT) is a popular approach rather than traditional grammar-based approaches such as English language education in Turkey (Ortaçtepe & Akyel, 2015). In addition, CBI has essential features such as language learning by academic content, engagement in activities, proficiency development in academic discourse and improvement of efficient learning strategies (Crandal, 1987).

Content based instruction as a communicative approach

Content-based instruction can be implemented using communicative language teaching (CLT) (Crandal, 1987). Communicative language teaching became popular in the early 1980s especially in North America and Great Britain (Nunan, 1989). The theory of communicative competence is based on the idea that language acquisition is more than knowing the rules of grammar or language competence (Hymes, 1972). Brown (1994) supports this idea by listing four characteristics of the communicative approach within CBI: (a) classroom goals focused on communicative competence rather than grammatical or linguistic competence; (b) language techniques designed by considering pragmatic, authentic and functional use of language; (c) fluency and accuracy underlying communicative competence; and, (d) classrooms in which students have to use the language productively in natural context. Thus, communicative competence had a great impact on the field of second language learning and teaching.

A great emphasis of CLT is that language acquisition can be achieved best when it is learned with communication purposes in meaningful and significant social contexts, not as the object of analysis in classroom (Brumfit & Johnson, 1979). According to Crandall (1995), CBI can be utilized in diverse ways by using not only traditional teaching methods but also contemporary approaches such as CLT. Content-based instruction, perhaps more than any other method, can foster the communicative competence in learners and support students to become autonomous learners with the combination of communicative approach (Stryker & Leaver, 1997).

In order to investigate the culture of communicative competence and second language proficiency in classrooms, a research-project, *The Communicative Orientation of Language Teaching (COLT) Observation Scheme,* was developed in the early 1980s in Toronto, Canada. The *Communicative Orientation of Language Teaching (COLT): An observation scheme* which is an instrument utilized in the observation of teaching and language learning in classrooms by focusing on the communicative features of verbal exchanges between teachers-students, and students-students (Spada & Fröhlich, 1995). According to the COLT categories, in order to describe a class as more communicatively oriented, in that class, the teacher spends more time focusing on meaning and group work interaction (Spada & Fröhlich, 1995).

Content based instruction in mathematics

The arguments for teaching English as a second language through mathematics started in the early 1980s in the United States (Cuevas, 1984). This issue then became a base around the world which enables educators to develop effective teaching of English language learners (Campbell, Davis, & Adams, 2007).

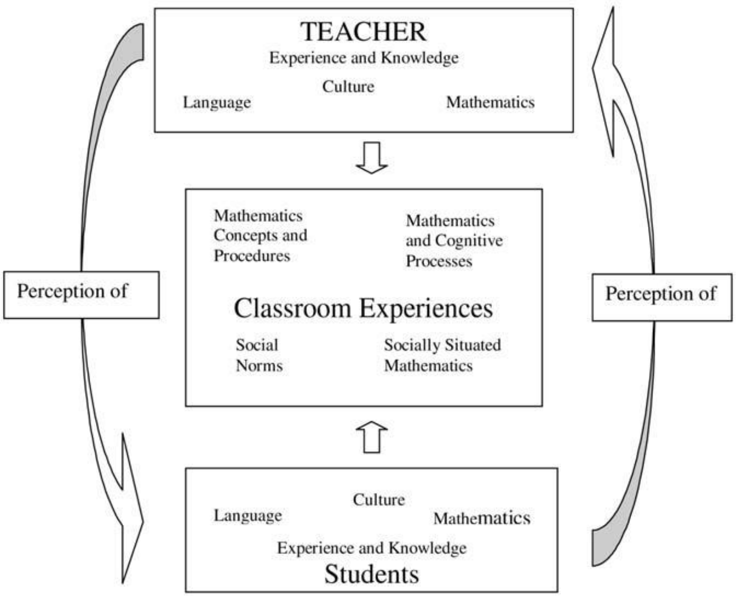

Figure 1. Model of interactions in mathematics teaching and learning

According to Campbell, Davis, and Adams (2007), there are three critical components of mathematics pedagogy as illustrated in Figure 1:

> the classroom as a socially constructed learning environment mediated through teacher–student interaction; the teacher's perceptions of the students and classroom environment mediated by the interaction of experience and knowledge, language, culture, and mathematics; and the students' perceptions of the classroom environment mediated through the interaction of language, culture, mathematics, prior experiences, and knowledge. (p. 17)

These components shape the expectations of the teachers and the students about the meaning of learning and teaching mathematics and shape the instruction (Campbell, 1995; Tikunoff, 1985). According to the fieldwork of Campbell (1992) on public school content-ESL teachers working with Southeast Asian refugees, more important than developing language and the content for teachers is to the need to develop critical elements of instructional materials and activities presented in mathematics classes where English is the only language of instruction. Campbell's (1992) work emphasized the importance of "the relationship among language, life experiences, culture, and instructional content" (p. 4) in the classes where the students are from a variety of language groups and are taught English through a focus on teaching content using ESL strategies.

Teaching mathematics and learning mathematics require more than just the inclusion of mathematical content. For example, Boero, Douek, and Ferrari (2008) suggest that natural language as "a mediator between mental processes, specific symbolic expressions, and logical organizations in mathematical activities" (p. 243) plays an important role in mathematics learning. Khisty (1995) stated that the nature of the language used to communicate mathematical ideas "needs to be brought to the students' attention and its structure needs to be taught, along with the rest of mathematics, in order for students to develop sufficient control in its use as a way of communicating mathematically" (p. 283). Moschkovich (1999; 2012) highlighted that ESL students need to experience both the development of mathematical content and argumentation practices, as well as to experience building vocabulary.

Mathematical discourse

Discourse is an instructional strategy such that amongst teachers and students it plays a significant role in nurturing students' development of conceptual mathematical ideas and in-depth knowledge (Brendefur & Frykholm, 2000; Davis, 1997; Kazemi, 1998; Knuth & Peressini, 2001; Lo & Wheatley, 1994; Martino & Maher, 1999; National Council of Teachers of Mathematics [NCTM], 1991, 1996; Peressini & Knuth, 2000; Silver & Smith, 1996; Pirie, 1996). The National Council of Teachers of Mathematics (NCTM, 1991) in their professional standards describe discourse as the ways of representing, thinking, talking, agreeing and disagreeing about mathematics in an environment in which students engage.

As discourse is more than a language (Gee, 2014), mathematical discourse is much more than the use of technical language (Moschokovich, 1998) which involves multiple modes, representation (gestures, objects, drawings, tables, graphs, symbols, etc), diverse perspectives, reasoning, revoicing and making sense of mathematical ideas as well as providing mathematical justification (Chapin, O'Connor, & Anderson, 2009; Moschokovich, 2006; Molle, Sato, Boals, & Hedgspeth, 2015). The content of mathematical discourse is the mathematical substance of the comments, questions, and responses that arise which considers both theoretical and practical understandings of the nature of the teacher's role in a discourse and teacher's own learning (Fennema et al., 1996; Hufferd- Ackles, 1999; Mason, 2000; Sherin, 2002;

Thompson & Thompson, 1996). Furthermore, the content of the mathematical discourse is related to how closely the ideas used in discussions overlapped with the teacher's curricular goals and with mathematics as it is understood by the mathematical community (Ball, 1996; Jaworski, 1994; Nathan, Knuth, & Elliott, 1998; Sherin, 2002; Silver & Smith, 1996; Wood, Cobb & Yackel, 1991).

According to Piccolo et al. (2008), specific conversations of the discourse should be verified in terms of learning outcomes; that is, "communicating to learn mathematics rather than learning to communicate mathematically" (p.379). NCTM Standard 5 (2007) emphasizes that the roles of a teacher of mathematics should be to raise open-ended questions in order not to restrict the diversity of responses and to ensure a productive mathematical discourse.

Asking consistent questions to promote discourse is an integral part of the teaching and learning mathematics in a classroom and it could facilitate the development of students' mathematical critical thinking (Davis, 1997; Elliott & Kenney, 1996; Kazemi, 1998; Knuth & Peressini, 2001; Lo & Wheatley, 1994; Martino & Maher, 1999; NCTM, 1989; 1991; 1996; 2000; Pirie, 1996). Well-prepared questions scaffold students' engagement with the task and the nature of the classroom environment. This encourages students to provide the correct answer to the question, and gives students the chance to learn high-level mathematics (Boaler & Brodie, 2004; Kazemi & Stipek, 2001; Smith, 2000; Stein, Remillard, & Smith, 2007; Wood, Cobb, & Yackel, 1991). Additionally, according to Brahier " the difference between a strong lesson and a weaker one often lies in the teacher's ability to raise clear but critical questions with artistry" (2010, p. 193). With this sentence, Brahier summarizes the importance of questioning in the classroom discourse. Brahier (2010) and Martino and Maher (1999) emphasize another significant point that open-ended questions let the students explain their solution in several different ways although these questions might have one correct response. Further, several researchers suggest that effective questioning enhances teacher development in terms of diverse students and the socio-cultural contexts of mathematics learning in their school settings (Bellack, Herbert, Hyman, & Smith, 1966; Carlsen, 1991; Cazden, 1988; Dillon, 1988; Franke et al., 2009; Hart & Allexsaht-Snider, 1996).

However, creating and maintaining an effective mathematical discourse environment is a complex endeavor for teachers. Teachers are expected "to encourage students to share their ideas and to use these ideas as the basis for discussion (the *process* of mathematical discourse) and simultaneously "to ensure that these discussions are mathematically productive (the *content* of mathematical discourse)" (Sherin, 2002, p. 205). NCTM (1991) *Teaching Standards* recommends that mathematics teachers initiate and “orchestrate discourse by posing questions that elicit, engage, and challenge students’ thinking,” by “listening carefully to students’ ideas,” and by “asking students to clarify and justify their ideas orally and in writing” (p. 35). In order for questioning to be effective, it should include combinations of *evaluation* of what students know about the topic (Dillon, 1988; Winne, 1979), *guidance* towards specific understandings (van Zee & Minstrell, 1997), *emergence* of discussion, or *control mechanism* for progress of the lesson (Gall, 1984; Mehan, 1985; Stevens, 1912). As Piccolo et al. (2008) stated:

> The potential for rich, meaningful discourse can occur when teachers ask questions that resemble the logical thinking process for solving a problem (explanation), when the teacher engages students by asking if is there is

> another way to solve the problem (justification), or when the teacher asks questions that extend beyond rote memorization (p. 375).

Properly managed classroom discourse enables students to focus on sense making and reasoning; it enables teachers to evaluate students' understanding and to foster conceptual understanding and mathematical thinking (Boaler & Greeno, 2000; Kazemi, 1998; Piccolo et al., 2008; Simon & Blume, 1996; White, 2003). Therefore, as Ball (1993) claims, mathematical discourse should be used in mathematics education because it enhances students in doing mathematics, conjecturing, reasoning and defending one's ideas while learning mathematics.

International education

International education focuses on global issues or deals with typical foreign issues not only one particular country or culture. Contrary to popular belief or based on the meaning of the word "international," it is neither a teaching of students of different nationalities nor a study of the history, geography or custom of other countries. According to Hayden (2006), international education is "an inclusive umbrella term" which includes several interpretations or it is "a Venn diagram in which different concepts overlaps to varying degrees" (p. 5). Hayden (2006) maintains her ideas as that international education is the education experienced by people in international schools; however, it may also be experienced in national schools in case this experience is facilitated for students by building appropriate occasions.

On the other hand, international education includes a balanced formal curriculum according to one of international programs implemented in international schools, for example, International Baccalaureate Organization (IBO, 2013) or Cambridge

International Examinations (CIE, 2014). According to IBO (2013), international education aims to educate students as an international-minded individual. Also, the philosophy of international mindedness in these schools is to create and sustain authentic global learning communities.

International schools provide students from all around the world a great opportunity to a multicultural K-12 education. These students also can learn to communicate with a variety of languages thanks to the multicultural environment. Therefore, in the multicultural environment of international schools, students can interact with other students from diverse cultures in a colloborative environment (Banks & Banks, 1995; Lauder, 2007).

CHAPTER 3: METHOD

Introduction

This ethnographic study focuses on the culture of a content-based English/Mathematics classroom at an international school in Turkey. Twenty-one multicultural secondary-level students who learn mathematics in a language (English) different from their native language and an international mathematics teacher (native English speaker) participated in this study. In this sense, the study aims to describe the mathematical discourse related mathematics teaching and the communicative discourse of communicative language teaching in a multicultural content-based classroom.

Research design

To fully understand the culture of a content-based English/Mathematics classroom regarding secondary-level students' mathematical and communicative discourse, this study undertook an ethnographic exercise at an international school in Turkey. Ethnography is a fundamental tool for understanding and learning the classroom environment through the eyes of the students (Spradley, 1980). Another reason for choosing an ethnographic framework is that it is one of the best qualitative approaches to describe the mathematical and communicative discourse in the multicultural content-based English/Mathematics classroom.

This study aimed to explore the shared patterns of the content-based classroom; however, the patterns could not be easily discerned through questionnaires or brief encounters so the researcher went to the field to make observations (Denzin &

Lincoln, 2000). That is, this study was conducted in the field by directly interacting with the participants of this research. Within the naturalistic framework, the researcher tried to minimize the "distance" or "objective separateness" (Lincoln & Guba, 1985, p. 94). As a participant observer in the field, the researcher gathered extensive field notes and collected documents to record the behavior of culture-sharing group; that is, the secondary level students who were taught mathematics by the same mathematics teacher and in the same mathematic classroom (Wolcott, 1999). As an ethnographer, the researcher looked for the culture of a content-based classroom through mathematical and communicative discourse when the students were doing mathematics in their classroom environment.

Context

The study was conducted at an international school in Turkey where the medium of the instruction is exclusively English. In the school, there are both foreign (English speakers) and native (Turkish speakers) students. The school provides a rigorous academic program to students from the International Baccalaureate (IB) Primary Years Program in Kindergarten through the 12th grade IB Diploma. The school's English immersion early childhood program progresses to the bilingual and multilingual grades with the mandatory international English programs of the Cambridge IGCSE and the IB Diploma Program.

The observations were carried over a selected group of secondary-level multicultural students (21 students) and a foreign (native English speaker) mathematics teacher in a content-based English/Mathematics classroom. The classroom chosen in this study was a special class because it was a multicultural classroom in which more than 50 percent of the students is Turkish. Moreover, the teacher's teaching technique is different than the traditional ones, which was lecturing. That is, the teacher applied the inquiry-based questioning techniques during the mathematical discourse.

Participants

The participants of this study were 21-secondary-level multicultural students and an international mathematics teacher (native English speaker) at an international school in Turkey. The students' ages ranged between eleven and thirteen years. There were eleven male students and ten female students in this content-based English/Mathematics classroom. Eleven of the students in this class were foreign but only a few of them had English as mother tongue while ten of them were native Turkish speakers. However, these students were taught at international schools right from the primary school where the medium of instruction was English. The families of these students were from the upper middle classes. The teacher is a native English-speaking international mathematics teacher. She was teaching for more than ten years in different international schools.

Instrumentation

The main data instrument was the researcher as a participant observer. As the researcher and a student-teacher, the researcher was the main qualitative collector for this one-semester-long ethnographic study. The researcher also studied at one of the best universities in Turkey, Middle East Technical University, in which content-based instruction is given. Moreover, the researcher (native Turkish speaker) also studied mathematics in this university where the medium of instruction was purely English. Therefore, the researcher was aware of the content-based classrooms.

The data were the audio recordings gathered through 17-seventh grade lessons consisted of 540 minutes of course-time. These observations included student-teacher interactions as well as student-student interactions in their natural settings, the content-based English/Mathematics classroom environment. In addition, the data were enriched with the detailed field notes, researcher journals and course materials-the documents and notes used in the lessons. Transcripts of classroom observations were used as preliminary data source for the analysis but, field notes, lesson materials, and audio recordings were kept for the analysis procedure.

Data collection

Data were obtained by participant observation (Spradley, 1980) through observations in a content-based English/Mathematics multicultural classroom. To understand "the patterns of a culture-sharing group" (p. 473), who were multicultural secondary-level students in this research, the researcher spent considerable time -visited once or twice a week in one semester- in their mathematics classroom (Creswell, 2008). The researcher made broad descriptive observations "to understand their culture-sharing behaviors and language" (p. 473) by making trying to get an overview of how the participants behaved in their natural classroom environment (Creswell, 2008). As a master student and a student-teacher, the researcher learned how to observe and discover things from the participants' point of view. Observations were made on how these students did mathematics, how they expressed themselves mathematically or communicatively, and how the teacher encouraged students to participate in mathematical and communicative discourse.

During the fieldwork, seventh grade students who were taught in a language (English) different from their native one were observed while they were doing mathematics. The researcher observed this content-based classroom during 17 separate lessons from September to December. During these lessons, the researcher sat at the back of the room with her journal and tape-recorder. As part of collecting data, participants' learning environment was described in detail within the ethnographic framework, and classroom discourses were audio-recorded. In conjunction with the audio-recordings, communicative details including overlapping speech, rises in pitch and volume, teacher's non-verbal actions such as eye contact, posture or writing on the board, distributing materials, and students' behavior were recorded as field notes. Hence, the data were enriched with these field notes, researcher journals and course materials.

The researcher considered the ethical issues before conducting the data because "every ethnographer, whether student or professional, should consider a number of ethical issues in doing fieldwork" (Spradley, 1980, p. 20). One ethical rule is not to gather the data without the consent of the participants. Hence, this study is conducted with the selected participants who agreed to participate in this research. Before collecting data, the participants were informed in detail about the content of research and confidentiality issues. All steps were conducted on voluntary basis. The journals and audio-records were shared with the participants. The participants' identities were kept anonymous and the recordings were not shared with third parties.

Data analysis

After the data collecting process, data were analyzed through description, analysis and interpretation of the culture-sharing group (Wolcott, 1994; Creswell, 2008). The observations over a prolonged period of time of the secondary-level students' mathematical and communicative discourse provided the detailed description of the culture of the content-based classroom. As a participant observer, the researcher transcribed the data in detail, inserting comments and indicating non-verbal interactions as they arose in transcription, combined them with the field notes and course materials to assure consistency.

The data analysis began with reading transcribed audio-recordings, and re-reading and listening several times in order to gain a detailed understanding of the culture of content-based classroom. Two different methods in the analysis were followed: qualitative method by using analytic induction (Bogdan & Biklen, 1992) for the mathematical discourse and descriptive method by using a research-based observation scheme for the communicative discourse.

In the first step of the data analysis, the transcribed classroom discourses were analyzed qualitatively to examine the mathematical discourse in this classroom. The reason for using qualitative perspective is that it allows the researcher to describe the whole classroom discourse and routines in naturalistic settings (Carlsen, 1991; Lincoln & Guba, 1985). To this end, a separate set of analysis was conducted for each mathematics lesson by using method of analytic induction (Bogdan & Biklen, 1992) to identify the characteristics of mathematical discourse. The researcher took a view of mathematical discourse as more than the use of technical language (Moschokovich, 1998) and considered it as talking, acting, interacting, thinking, believing, reading, writing about mathematics and representation (gestures, objects, drawings, tables, graphs, symbols, etc), justification, reasoning, problem solving, to engage in mathematics, to discover important mathematical concepts, to conjecture and make-sense of mathematical ideas and to stimulate mathematical thinking which emerge between students and teacher or within a group of students in the classroom (Brahier, 2010; Gee, 2007; Moschkovich, 1999; 2007; NCTM, 1991, 1996, 2007; O'Connor & Michaels, 1993; Sfard, 2008).

In order to code the transcripts, each classroom observation was divided into manageable sections with respect to the divisions that occurred naturally in the sequence of classroom events, such as the end of a discussion for a particular problem/exercise. Transcripts of classroom observations were first analyzed by examining the student-teacher utterances to identify a preliminary coding scheme which provided an initial insight about the culture of a content-based classroom regarding the mathematical discourse. From this preliminary scheme, repetitive codes were identified and the sections were analyzed thoroughly to identify patterns and routines in mathematical discourse, recording the importance of characteristics of mathematical discourse. Subsequently, these patterns were categorized into themes based on the culture of a content-based English/Mathematics classroom in terms of mathematical discourse. During this process, the meaning of a single word was not examined; instead, the situated meaning of the student-teacher utterances was considered (Moschkovich, 2004).

In the second step of analysis, descriptive analysis method was applied and transcripts of classroom observations were coded and categorized according to the *Communicative Orientation of Language Teaching (COLT): An observation scheme* which is an instrument utilized in the observation of teaching and language learning in classrooms by focusing on the communicative features of verbal exchanges between teachers-students, and students-students (Spada & Fröhlich, 1995).

Communicative Orientation of Language Teaching (COLT) was developed in the early in 1980s for a research project in Toronto, Canada, to examine the nature of L2 language proficiency and its development in classrooms. The COLT observation scheme has two parts: Part A of the scheme is done during the observation simultaneously, and Part B is done after the observations by using the transcripts of the audio-recordings. Part A is more applicable to a language teaching classroom and the items in the observation scheme were not relevant to this particular context in a mathematics classroom so that Part A was not used in this study. Hence, only Part B of the scheme was used to analyze the communicative features of verbal exchanges between teacher and students who participated in this study. Additionally, some of the categories of Part B of the observation scheme were removed from the scheme because they were unnecessary or not appropriate for this study. A full length version of the Part B can be found in Appendix A.

The Part B analysis focuses on the verbal output and interactions of teacher and students so that it is detailed. There are five major communicative features in Part B: *Use of target language, information gap, sustained speech, reaction to form or message, and incorporation of student/teacher utterances.* In Part B, the number of communicative features and their categories are differentiated for teacher verbal interaction and student verbal interaction (Spada & Fröhlich, 1995).

CHAPTER 4: RESULTS

Introduction

This ethnographic study focuses on the culture of a content-based English/Mathematics classroom at an international school in Turkey. The study investigated (a) the characteristics of mathematical discourse using analytic induction (Bogdan & Biklen, 1992) and (b) the communicative discourse using Communicative Orientation of Language Teaching (COLT) observation scheme which is an instrument utilized in the observation of teaching and language learning in classrooms (Spada & Fröhlich, 1995; Ortaçtepe & Akyel, 2015).

The results will be presented by addressing the following pair of questions central to content-based instruction:

How can the culture of an English/Mathematics classroom be described in terms of

(1) mathematical discourse?

(2) communicative discourse?

Results

The patterns of mathematical discourse in the content-based classroom

Before introducing the characteristics of the mathematical discourse in naturalistic settings, in order to get a general insight it would be useful to talk about the patterns of teacher-students utterances in this classroom. The researcher observed the application of 104 routine and 22 non-routine word problems, several topics such as algebraic fractions, grouping symbols, factorization, percentage, ratio and profit have been covered. Initially, in Ms. Piaf's (pseudonym for the teacher) class, each lesson began with the review of the homework, and for rest of the lesson teacher spent some time explaining to students the problems they were going to work on.

The following excerpt, Excerpt A, occurs in a lesson starting with solving a simple algebraic fraction problem, and for the rest of the lesson, the class works on factorization which will be presented in Excerpt B[1] in the following pages. These excerpts and the following ones are chosen purposefully because they are good examples of all the features of the mathematical discourse. In the excerpts, conversational turns are numbered for ease of reference and square bracket expressions, "[]", show non-verbal information to help with references. In the student-teacher verbal interactions, pseudonyms are chosen to reflect the cultural background of the children and the teacher to protect their identity. Excerpt A below demonstrates the patterns of a mathematical discourse in Ms. Piaf's classroom.

[1] In order to understand the nature of mathematical discourse in natural settings, the majority of discourse is illustrated in both Excerpts A and B which are continuation of each other and occur in the same lesson.

Excerpt A

1. **Teacher (T):** Alright. Questions? [Pause] Fyodor?
2. **Fyodor:** I couldn't do question (3a).
3. **T:** (3a): x over two minus x plus one over three [$\frac{x}{2} - \frac{x+1}{3}$] Ok. Ezgi?
4. **Ezgi:** First we have to make the denominator same.
5. **T:** Make denominator same. Which is?
6. **Ezgi:** Six.
7. **T:** Six. So I've got to multiply this by? [showing the denominator of $\frac{x}{2}$]
8. **Ezgi:** Three.
9. **T:** Three and by three [showing the numerator of $\frac{x}{2}$] and this by? [showing denominator of $\frac{8x+1}{3}$]
10. **Ezgi:** Two.
11. **T:** Two. And this whole thing by two. I am gonna write the numerator, three x minus two bracket x plus one. [$\frac{3x-2(x+1)}{6}$] Go on Ezgi! Remove the brackets.
12. **Ezgi:** Three x.
13. **T:** Three x, minus?
14. **Ezgi:** Two x.
15. **T:** Two x, minus?
16. **Ezgi:** Two.
17. **T:** Two, over?
18. **Ezgi:** Six.
19. **T:** Six. Gandhi, why minus two? [$\frac{3x-2x-2}{6}$]
20. **Gandhi:** Because the minus plus one [Pause] Oh, no because the plus in the step over and [Pause].
21. **T:** And then?
22. **Gandhi:** And then you subtract it.
23. **T:** What?
24. **Gandhi:** I don't know how to say it.
25. **T:** You listen to Martin.
26. **Martin:** Because you're subtracting them both.
27. **T:** Aaa, we are subtracting them both? Vera?
28. **Vera:** Because negative times positive is negative.
29. **T:** Good! Negative two times positive one that's why minus two. Ok? Simplify the numerator, Maya. My answer would be?
30. **Maya:** Ee... [Pause] x.
31. **T:** x?
32. **Maya:** Minus two.
33. **T.** Over?
34. **Maya:** Six. [$\frac{x-2}{6}$]
35. **T:** Ok? Alright. One more question from (3). One last example from who hasn't asked, Anthony?
36. **Anthony:** (3k).
37. **T:** (3k). We've got three minus x over two, minus x minus four over six.

...

As shown in Excerpt A, at the beginning of the lesson, the teacher wants the students to identify the challenging problems for them in their homework (e.g., 1, 35 in Excerpt A)[2]. Ms. Piaf then starts to work on the problems of each student after introducing the problem to the whole class (e.g., 3, 37). She does not give any direction to solve the problems; instead, she poses a series of simple, closed and leading questions (e.g., 5, 13, 15, and 17 in Excerpt A). Thus, the students usually give short answer responses (e.g., 6, 8, 10, and 18 in Excerpt A). If the student gives the desired response, the teacher repeats the student's response and poses a leading, follow-up question (e.g., 13, 15, and 17 in Excerpt A). The teacher evaluates them by repeating student's response such as in turns (e.g., 7, 9, and 19 in Excerpt A) or by simple comments as in (29 in Excerpt A). Therefore, in this classroom, the pattern could be described as: a request for information raised by teacher, and a simple response of the student, then a comment or a leading question given by the teacher.

Characteristics of mathematical discourse in the content-based classroom

Transcripts of classroom observations are analyzed by addressing the characteristics of mathematical discourse in the content-based classroom. After analysis, four themes emerge: (a) use of the language of mathematics, (b) use of strategies, methods/ways of solution and different perspectives, (c) use of mathematical reasoning and mathematical justification, and (d) use of connection between mathematical ideas/concepts and extension in mathematical thinking.

Use of language of mathematics

The thematic analysis of transcripts reveals that *the use of language of mathematics* is one of the characteristics of mathematical discourse in this content based

[2] Numbers in parenthesis refer to lines in the protocol.

classroom. Language of mathematics is more than technical language (Moschokovich, 2012) although some researchers use this term as mathematical vocabulary (e.g., Sfard, 2008). During this study and analysis procedure the language of mathematics is considered as not only vocabulary but also the word usage in a mathematical context (Moschokovich, 2012). To put it more clearly, the following teacher-student utterances (Excerpt 1) from a day in which percentage word problems were taught is utilized:

Excerpt 1

Teacher: ..."In order to borrow enough money to buy a house, Skye needed to have 28% of the cost of the house she choose. If the home cost $425000, how much money does she need?" [Problem]. Ok. Wait for a while. Think of again. Let's read again. "In order to borrow enough money to buy a house, Skye needed" Right. How many percent does he need to buy the house? How many percent does she need? Ekin?

Ekin: Twenty eight percent [28%].

Teacher: Good! Twenty eight percent. Can you see the word twenty eight percent?

Ekin: Yes.

Teacher: "Of" Can you see the word "of"?

Ekin: Yes.

Teacher: What does it remind you?

Ekin: Times.

Teacher: Good! "Of the cost of the house". How much did the house cost him?

Ekin: Four...

In the Excerpt 1, the teacher asks the student (Ekin) what the word "of" means in the problem and the student's response is "times" so that the word "of is applied within the language of mathematics because it gains a mathematical meaning when it is used in a mathematical context. Further examples of use the language of mathematics in content-based classroom are highlighted in Excerpt A above and Excerpt B below [This is a continuation of Excerpt A with the number (37) repeated to demonstrate the continuation].

Excerpt B

37. **T:** (3k). We've got three minus x over two, minus x minus four over six. [$\frac{3-x}{2} - \frac{x-4}{6}$]. Ok, so I'm changing it to? [referring the denominator]
38. **Class:** Six.
39. **T:** Six. Alright. Anthony, you tell me where did you go wrong? So you multiply this [by showing $\frac{3-x}{2}$] by?
40. **Anthony:** Three.
41. **T:** Three. So the whole thing by three. Go on. What should you write on the numerator?
42. **Anthony:** Nine.
43. **T:** Three, I don't want to extend yet. So three?
44. **Anthony:** Eee...Three nine.
45. **T:** Three? Copy down the numerator. Three, bracket?
46. **Anthony:** Three minus x.
47. **T:** Hıhı, minus?
48. **Anthony:** Minus x minus four. [$\frac{3(3-x)}{3(2)} - \frac{x-4}{6}$]----> [$\frac{3(3-x)-x-4}{6}$]
49. **T:** Where did you go wrong here?
50. **Anthony:** I am not sure about where I am wrong.
51. **T:** Where you've gone wrong I am gonna, he is gonna tell you, Mete?
52. **Mete:** I did this as every single question.
53. **T:** Now you know what to do?
54. **Mete:** We have to put bracket. [$\frac{3(3-x)-(x-4)}{6}$]
55. **T:** Very good! You're subtracting everything in the second one. So now we remove the brackets. So go on Anthony. This is[$3(3-x)$]?
56. **Anthony:** Nine.
57. **T:** Nine minus?
58. **Anthony:** Three x.
59. **T:** Three x? We're multiplying in negative one here[$\frac{3(3-x)-1(x-4)}{6}$]. Go on Anthony.
60. **Anthony:** Negative [Pause] negative x.
61. **T:** Negative x?
62. **Anthony:** Minus.
63. **Class:** No, plus!
64. **Anthony:** Plus.
65. **T:** Plus! Negative and negative is plus. Plus?
66. **Anthony:** Four.
67. **T:** Over?
68. **Anthony:** Six. [$\frac{9-3x-x+4}{\mathbf{6}}$]
69. **T:** Ok? So combine the like terms, [$\frac{9-3x-x+4}{6}$] Demir?
70. **Demir:** Eee ok, three x minus x equals two x.

71. **T:** Aaaa! Three x minus x equals two x?
72. **Demir:** Aaa, minus three x minus x.
73. **T:** Minus three x! Remember, you've got to take the sign!
74. **Demir:** Minus four x.
75. **T:** So nine and fourteen, sorry nine and four?
76. **Demir:** Plus thirteen.
77. **T:** Thirteen. Negative three x subtract x?
78. **Demir:** Four x.
79. **T:** Four x, over?
80. **Demir:** Six.
81. **T:** Ok. Alright.

[At this point, the teacher started a new topic, factorization]

82. **T:** Alright. What we did before …If you put two bracket two x plus three [2(2x+3)]. And I want you to remove the brackets. Now in math when you remove the brackets, it's called?
83. **Class:** Expansion.
84. **T:** 'Expansion'. Ok? You're expanding it. Now, remember what Lucia said, we use the distributive property. What did we do, we multiply two into every single one in the bracket. Right?
85. **Class:** Yes.
86. **T:** Removing the grouping symbols we extend it. So what do we get, when you use distributive property? Gandhi?
87. **Gandhi:** We got four x.
88. **T:** Four x?
89. **Gandhi:** Plus.
90. **T:** Plus?
91. **Gandhi:** Six.[4x+6]
92. **T:** Alright. Today, we're going to do the reverse. The reverse is called?
93. **Class:** Factorization.
94. **T:** Factorization. Comes from the word?
95. **Class:** Factor.
96. **T:** Factor. What's happen here as we wanna see. How can we do the reverse? Meaning: if I give you four x plus six [4x+6], how can I get two, bracket, two x plus three [2(2x+3)]?
97. **Class:** Oooo! [surprised]
98. **T:** So this is what we gonna do. Ok? Oh, you know what to do?
99. **Mehmet:** Yes.
100. **T:** Oh, wait! No, wait! Alright. So we did expansion before. So, expansion is multiplying two in you get four x plus six. We use, what property did we use over here?
101. **Gandhi:** Distributive.
102. **T:** Distributive property, alright. Now we're going to see today how can we do the reverse. So, if I give you four x plus six [4x+6], I want you to get two, bracket, two x plus three [2(2x+3)]. Alright. Is there anyone who has them this before? And, or, maybe hasn't that them before but that maybe, this can work, my method can work? From four x plus six to get to two bracket

two x plus three. Onat, you come to the board and explain before I show the video.

103. **Onat:** Eeee.Ok, maybe you need to find a common thing to multiply both of them.
104. **T:** Ok, common thing means?
105. **Martin:** Denominator.
106. **T:** Common thing means common factor. Write a word "common factor" Alright. So, that's a very important word in factorization. Common factor. Alright. Go on.
107. **Ahmet:** Are we writing?
108. **T:** No! Don't write. Because we're trying to figure out as a group, what's going, what you have to do in order to factorize. Ok. So the common factor is?
109. **Onat:** Two.
110. **T:** Two. For what? For which one?
111. **Onat:** Both of them.
112. **T:** For both of them. So, for four x and for six [4x+6], the common factor is two. Ok.

113. **Onat**: When you divide both of them by two in the bracket we will be four x divided by two is two x and six divided by two is three.
114. **T:** So, plus three. That's what he did. Look at the terms. Then he said let's take up the common factor. And the common factor for four x and six is two. Is he right for four and six is two?
115. **Class:** Yes.
116. **T:** Ok, so that's the common factor. So he said put the common factor outside the bracket. How did he get the terms inside the bracket, Demir? He?
117. **Demir:** Eeee...[Pause]
118. **T:** How did he get two x plus three in the bracket?
119. **Demir:** He divided by the common factor.
120. **T:** He divided by the common factor. Ok. That makes sense, that makes sense? Let's try another example using Onat's method. If I have twelve x plus sixteen [12x+16]. Ok. I want you to use Onat's method. Onat said get the common factor, take it out, put the others in the bracket, after you divided it by the common factor. Deniz, you're going to explain the class what you need to do. So what's the common factor?
121. **Deniz:** If I go by Onat's way, first of all, I need to find the way that divided by [pause]
122. **T:** Not the way, what was the word!
123. **Class:** Common factor.
124. **T:** Common factor is the word! Which is?
125. **Deniz:** Eight.
126. **T:** Eight?
127. **Class:** No! Four, two...
128. **Deniz:** Onat has been two, we have to simplify it.
129. **T:** No no no! So you do what you want.
130. **Deniz:** Six.
131. **T:** Six?
132. **Class:** No. Four.
133. **T.** Very good. So somebody says four. Is there anyone who says two?

134. **Gandhi:** It could be two.
135. **T:** It could be two. Good! So Onat says common factor. Some people say four and some people say two. Which is common factor? Which one would it be? Would it be two or would it be four? Because they're both common factors, they are not wrong. Which one should it be? One for Anthony.
136. **Anthony:** The biggest one.
137. **T:** Very good! When you take the common factor, instead of the common factor, it should be the?

138. **Class:** Highest.
139. **T:** Highest common factor, very good! What is the highest common factor?
140. **Anthony:** Four.
141. **T:** Four, ok go on. It is four. So what do I do inside the bracket?
142. **Deniz:** Three.
143. **T:** Three plus?
144. **Deniz:** Four.[4(3x+4)]
145. **T:** Four. Very good. Alright. We've got minus four x, negative four x plus twelve. [-4x+12]. Now look at the way how we factorize. What do you think the common factor would be? İlber?
146. **İlber:** Maybe four.
147. **T:** Four. Ok. So we think the common factor is four. Ok? We are not wrong. The common factor is four. But, because the x term is negative this is the way mathematically how we would do it.

…

As seen in all excerpts, the teacher is not interested in the grammar or vocabulary of the students; she mostly pays attention to the usage of language of mathematics. For example, in turns 103-106 and 121-124 in Excerpt B, to imply the "common factor", two students, Onat and Deniz, use their own words which are "common thing" and "the way", respectively. Ms. Piaf insists only on to use the correct terminology within the context of mathematics and does not correct grammar or vocabulary.

The teacher focuses on not only the accurate word usage in mathematical context but also its meaning in the corresponding context. More specifically, her focus is the usage of a mathematical term (sometimes a non-technical term) in mathematical context as illustrated in turns 93-96. In this turn, first, the teacher asks students for the word which is the reverse of *expansion* and students respond that it is *factorization* so that the students could learn both of the words: expansion and factorization. Then, the teacher also poses a further question for the meaning of the word: "Factorization, comes the word?" (94). This approach gives the teacher the chance to interpret whether students understood the concept and are able to provide reason. Moreover, to emphasize the meaning of the word in mathematical context further, the teacher occasionally *revoices* (Chapin, O'Connor, & Anderson, 2009) students' responses to express a mathematical term by using more technical terms (e.g., 55, 84, 114, 116 in Excerpt B) so that she facilitates students ingraining mathematical terminology thoroughly into their memory.

From the view of the student utterances, the analysis of mathematical discourse shows that students endeavor to use the language of mathematics (e.g., 4, 26, 28, 54 in Excerpt A; 84, 93 in Excerpt B). They are also supported, engaged or facilitated by the teacher in their use of the language of mathematics. Yet, most of the utterances between students-teacher or student-student illustrate that knowing a list of mathematical terms is sometimes necessary but not sufficient for participating in a mathematical discourse. For example, in turns 103-105 in Excerpt B, Onat uses the word *common thing* as a representative of the term *common factor* to explain his solution method. Because he uses this phrase in a mathematical context, what he wants to tell can be understood easily. Although the teacher accepts Onat's statement, she expects him to use the language of mathematics. Hence, the teacher of this content-based classroom emphasizes the importance of the use of the language of mathematics during the mathematical discourse by encouraging them to use language of mathematics so that the students are engaged in mathematical discourse.

Use of strategies, methods/ways of solution and different perspectives

The second characteristic of mathematical discourse in this content-based classroom is the *use of diverse methods of solution, strategies or different perspectives*. As there are infinitely many methods of solution or strategies that can be used to solve any mathematics problem, this characteristic is constructed of observations of different methods both the students and the teacher use during the mathematical discourse. In all excerpts, it could be seen as devising a plan before solving a problem or computation or as carrying out that plan and applying the method/strategy to the problem regarding various representation models. To illustrate, the following utterances between the teacher and students (Excerpt 2) and the picture of students' problem solution on the board (Figure 2) will show how students are allowed to express their ways of solution:

Excerpt 2

Teacher: "If twenty eight percent of a shipment of a book weighs five hundred and sixty kilograms. Find the weight of the shipment" [Problem]. Alright! So we've got ship. Ok. So we've got books. Supposing these are the books and I am going to ship this. This is all the books. And it says twenty eight percent of the books, supposing this is twenty eight percent of the books. This is twenty eight percent. Of the books weight, how much is the weight? This is whole shipment. This is whole stack of the books. Twenty eight percent of that, what's the weight of that? Ekin?

Ekin: Eee, I did in different ways.

Teacher: It's ok. I just want you to understand it visually.

Emmy: I did in different ways but I did it one hundred divided by twenty eight.

Teacher: Very good. So, one is Emmy's method and the other one is this method. And the third method will be cross multiplication.

Gandhi: I know the Indian method.

Teacher: The Indian method?

Gandhi: Yes. You can do it in less than two seconds. [Gandhi is at the board and showing the Indian method which is $\frac{560\times100}{28} = 2000$]

Teacher: In less than two seconds? Well done. Ok. Let's look at Indian way.

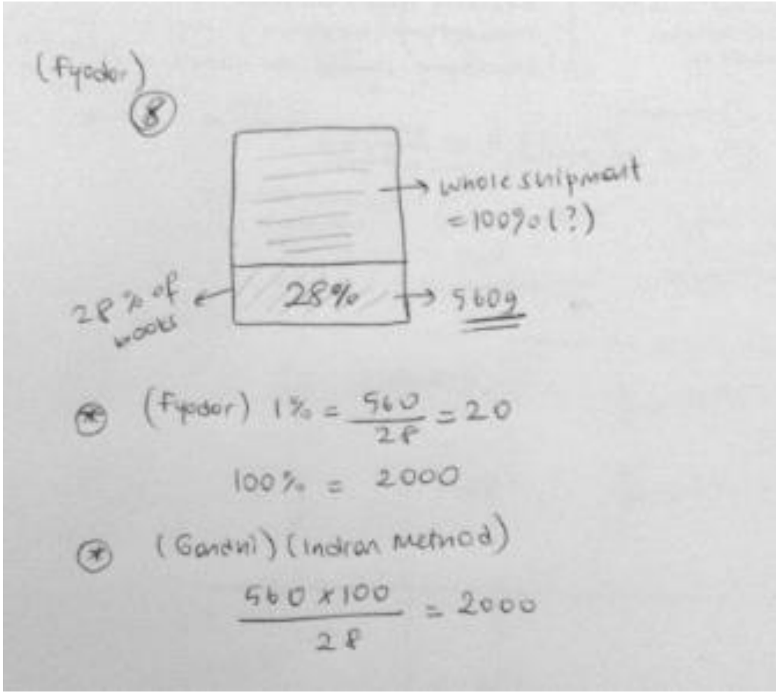

Figure 2. A picture of students' problem solution

As presented in the Excerpt 2 above as well as in the whole excerpts (Excerpt A and B), Ms. Piaf provides a free and relaxed environment for all students to share their ideas and to discuss different perspectives among the class so that she might engage students in mathematical discourse (see also 24-26 in Excerpt A). Moreover, the teacher wants all students to know that their ideas are valued. She facilitates all students getting the correct response but also expects them to use their own way to solve the routine or non-routine problems. For example, in turns 102-121 in Excerpt B, the teacher wants Onat to come to the board and show his method of solution. He explains his solution strategy to the whole class which helps him develop his communicative skills in mathematical discourse. Furthermore, another student (Deniz) uses Onat's method of solution on a new problem (121 in Excerpt B).

In general, the teacher establishes and maintains norms for discussions, asking students to listen to others, agree or disagree, and explain their arguments. As all students pay attention to each other's responses, ideas and strategies, they can react toward an incorrect response as in turns 63 in Excerpt A and 123 in Excerpt B. In this context, Ms. Piaf's main focus is to have students devise a plan and decide on the method or strategy, before working out the problems as in 103 in Excerpt B. This approach helps her interpret whether the students understand what the problem is and whether they have a plan for solving it. Moreover, it provides students like Gandhi, who do not have a strategy or method of solution (see lines 19–26 in Excerpt A) to realize several strategies can be used.

In a nutshell, the teacher of this class does not seem to be eager to show her solution method or her perspective; instead, she supports students to explore their own method or strategy because the students in this classroom bring a variety of ways of talking about mathematical situations to the discussion as presented in the extract above (Excerpt 2). The teacher, then, focuses more on students' thinking and their various solution strategies and less on the correct answer. To illustrate this clearly, when students incorrectly apply a procedure, the teacher poses a new question, elaborating on the question rather than demonstrating her solution method in order to generate new ideas or to make sense of their strategy. Alternatively, she allows another student to share his/her ideas with that particular student (51 in Excerpt A).

The teacher gives all students numerous chances to share their thoughts and ideas with the class. Allowing students to share their thoughts without judgment also seems to increase the number and variety of responses which improved the students' mathematical thinking during the mathematical discourse. As a result, the teacher can encourage students to state their answers in such a way that the students learn not only how the others think about the problems, but also multiple ways to think about and solve problems.

Use of mathematical reasoning and mathematical justification

Thematic analysis of transcripts reveals that *the use of mathematical reasoning and mathematical justification* is the third characteristic of mathematical discourse in this content-based classroom. In this study, reasoning, which refers to the process of examining and checking the reasonableness of any answer or any solution method to see whether the result is true, is used for the validation of thinking, while justification refers to the process of providing proof or the evidence of assumptions of the solution method, or for the correctness of the result.

In this content-based classroom, reasoning sometimes occurs in the middle of the solution, regardless of the final result or the exact answer of a problem. In order to inquire whether the solution steps would take the student to the correct result, the teacher helps students investigate why such a result has appeared during the corresponding solution step. For example, in turns 19-29 in Excerpt A, the teacher poses a question "Why minus two?" in $\left[\frac{3x-2x-2}{6}\right]$ after this step $[\frac{3x-2(x+1)}{6}]$. It seems that the student (Gandhi) does not know what the reason is behind such a computation, although his answer is accurate. Thus, he cannot respond to the teacher's question and he decides that he does not know after questioning himself. Then, the teacher asks another student (Martin) after reminding Gandhi to listen to his friend. Again, Martin could not provide the desired answer. The teacher still continues to make the students examine the reason rather than telling what the point is. This time, she lets Vera explain. Vera says that it is because "negative times positive is negative". As a result, this simple question facilitates all students to develop their mathematical thinking so that they will be aware of the reason behind this computation when they use it for upcoming similar problems.

Ms. Piaf also enables students to critically analyze their answers, to make interpretation and to explore where they go wrong and then to correct their own mistakes by themselves as in the case of Anthony (lines 39–51, in Excerpt B). In this content-based classroom, the teacher has a crucial role in guiding students to develop their reasoning skills which can be seen in several turns in the excerpts (e.g., 19-29, in Excerpt A, and 39-41, 49-50, 71-72, 94-95, 108-113, and 136-137, in Excerpt B). However, the teacher wants her students to be responsible for judging not only their own answers but also the answers and ideas of the others. To illustrate, the teacher wants a student (Demir) to explain how another one (Onat) solves the problem (see turns 114-119 in Excerpt B).

Although students are primarily expected to compute simple answers, they are able to hypothesize and justify their thinking with mathematical evidence as in (113). Moreover, in turns 133-138, while one of the students (Gandhi) makes a conjecture (134), the other one (Anthony) makes an interpretation (136) after the teacher's question (135) for Anthony to decide which answer is correct. Thus, after reasoning and justification, the students seem to rely more on themselves to determine whether their answer is correct or not and the teacher facilitated them by posing critical questions.

Use of connection between mathematical ideas/concepts and extension in mathematical thinking

Another characteristic of mathematical discourse is *the use of connection between mathematical ideas and concepts and extension in mathematical thinking.* This characteristic focuses upon making sense of mathematical and then extending these mathematical ideas. It is the way that both the teacher and the students examine how mathematical concepts are related to one another and how they would be applied in a new concept when the conditions change.

In line 82, in the Excerpt B, the teacher starts a new topic, factorization. But before introducing the term, she reminds students of the previous topic, expansion, by posing leading questions about an example of expansion problem. In turn 92, the teacher gives a signal for the new mathematical concept, factorization, by saying "Today, we're going to do the reverse". Therefore, she engages students by making a connection between opposite mathematical concepts as shown in turns 84-95. In addition, Ms. Piaf helps students to extend this new mathematical concept by posing a question: "How can we do the reverse?" and to provide the students the logic of it by showing an example. Those questions that the teacher poses allow students to make connections between their current knowledge and the new concepts of mathematics and then to extend their mathematical thinking by occasionally challenging or advancing questions as in turns (e.g., 96, 104, 137, 145 in Excerpt B). To illustrate, in turn 145, the teacher introduces a new problem of factorization [problem: what is the common factor of [(-4x+12)], which is an advanced question for the students because this mathematical expression [-4x+12] includes a negative term [-4]. The students are expected to make a connection with the previous problem [problem: factorize (4x+6)] in turn 102 and to apply the solution method of the previous problem into the new one. Therefore, Ms. Piaf's questioning patterns encourage students to connect their problem solving with their background knowledge (see 84-86, 92-96 in Excerpt B). She leads students to explore and make connection between mathematical concepts and apply one property to another as in 92-96.

To conclude, the analysis of mathematical discourse in a content-based classroom indicates that although the teacher most frequently poses a series of simple, closed and leading questions, students are supported to participate in mathematical discourse as the teacher does not provide direct information for students even though their utterances to the teacher's questions are generally short. This is because they are encouraged to explore and find their own solution methods or ways of representing the solution as well as the result of a computation. In addition, students are expected to justify their arguments or answers to a problem, or sometimes their method of solution. Furthermore, students are also quite eager to give reasons or to present diverse perspectives during mathematical discourse when the teacher gives them opportunities by posing critical questions.

Interestingly, one of the most remarkable results of the analysis is that the teacher emphasizes the necessity of using the language of mathematics and supports students to do so. She is interested in the usage of the correct word in the appropriate content of mathematics as well as the mathematical meaning of the word in the context rather than in the grammar or vocabulary of students. Moreover, in this content-based classroom, students' mathematical competence is enriched and reinforced by providing an environment in which the students discover the connection between mathematical concepts, make inference, and extend their mathematical thinking and mathematical knowledge. As a result, the students in this classroom learn and do mathematics by participating in mathematical discourse. Yet, in order to learn about the culture of a content-based classroom in terms of communicative language teaching, communicative discourse is analyzed by using Communicative Orientation of Language Teaching (COLT) observation scheme which is an instrument utilized in the observation of teaching and language learning in classrooms (Spada & Fröhlich, 1995).

The communicative discourse in the content-based classroom

Spada and Fröhlich (1995) developed an instrument for investigating the nature of second language and its progress in classrooms: *Communicative Orientation of Language Teaching (COLT): An observation scheme*. They divided the COLT observation scheme into two parts. While Part A of the scheme is done during the observation simultaneously, Part B is done after the observations by using the transcripts of the audio-recordings. In this study, only Part B of the COLT observation scheme was used to analyze the communicative features of verbal exchanges between teacher and students who participated in this study because Part A is more applicable to a language teaching classroom (e.g,, Deniz & Akyel, 2015) and the items in the observation scheme was not relevant to this particular context in a mathematics classroom. The complete version of the Part B can be found in Appendix A.

The general coding procedure for Part B is as the following: first, "check marks in the appropriate columns for any relevant categories of the teacher and a student turn - any speech which is produced by a speaker until another person speaking" (Spada & Fröhlich, 1995, p. 62). For example, if the teacher (or student) asks three pseudo questions in a turn, only one check mark is placed under *Penuine requests.* To get a general sense of how coding for Part B works, one excerpt from the transcripts of three different students is presented in Excerpt C.

Excerpt C

Teacher and student speech	Coding
Teacher: Minus three *k* squared *l* squared plus eight *l* squared *k* squared minus two l squared k squared divided by *kl*. Right, this is an algebraic expression. It has got lots of pronumerals, it does not matter how we do it. We always do it like directed number. Ok? So we have got subtraction, we got addition, and we got division. So remember we got not only numbers but also pronumerals. What will you do Maya?	L2/Predictable info & Pseudo request/ Sustained
Maya: I will divide.	L2/Predictable / Minimal
Teacher: So we gonna divide two, right? When you divide fraction, what was the easiest way we found the last time, Ekin?	L2/ Pseudo request/ Sustained/ Message-Paraphrase
Ekin: Write it like a fraction.	L2/Predictable / Minimal
Teacher: Good! Write it like a fraction. So we can reduce like a fraction. So we have two l squared k squared divided by kl [$(2l^2k^2/kl) \Rightarrow 2lk$] Can someone reduce this fraction, Gandhi?	L2/ Pseudo request/ Sustained/ Message-Repetition, Expansion, Comment
Gandhi: k and l.	L2/Predictable / Ultra-minimal
Teacher: k and ?	L2/Minimal / Message-Clarif. req.
Gandhi: k and k.	L2/Predictable / Ultra-minimal
Teacher: k and k. So how many k is left?	L2/Minimal / Message-Repetition, Elaboration req.
Gandhi: There is one.	L2/Predictable / Minimal

The next sections will present the results for each feature in COLT Part B.

The use of target language

The first category of the COLT observation scheme is the *use of target language*. It is a measure to investigate the frequency of L1 (use of native language) against L2 (use of the second/target language), in classrooms where the students share the same L1. In this research, even though the participants do not share the same native language, due to the multi-variety of classroom, more than half of the students in the classroom speak Turkish as their mother tongue. Therefore, the students and teachers use the target language in all their turns as illustrated in the Excerpt C.

Table 1
Target language used during teacher and student interactions

Target language	Teacher verbal interaction		Student verbal interaction	
	L1	L2	L1	L2
f	0	1617	0	1615
%	0	**100**	0	**100**

Furthermore, in order to interpret the data, the percentages of the usage of L1 and L2 are calculated in Table 1. Hence, findings reveal that the teacher and students share only the target language, English. Thus, this content-based language classroom adheres to the standards of communicative discourse, due the percentage of L2 use (100%).

Information gap

The second category of the COLT observation scheme is the *information gap.* This category is used for extending the information requested and/or exchanged which is not known in advance (Spada & Fröhlich, 1995). Information gap consists of four sub-major parts: *Giving information* (predictable-unpredictable) and r*equesting information* (pseudo request for information-genuine request for information). While giving *predictable* information refers to the information given which is generally followed as easily anticipated and known to the questioner, giving *unpredictable* information means the information given is not easily anticipated, including a wide range of information that can be provided. Moreover, a *pseudo request* is known in advance by the questioner and a *genuine request* is one that's not known in advance by the questioner. Table 2 indicates the result of the second category of the COLT observation scheme.

Table 2
Information gap between teacher and student interactions

Information gap	Teacher verbal interaction				Student verbal interaction			
	Giving info		Request info		Giving info		Request info	
	Pred.	Unpre.	Pseu. req.	Genuine req.	Pred.	Unpre.	Pseu. req.	Genuine req.
f	76	183	630	97	1346	178	0	34
%	7.7	18.6	**63.9**	9.8	**86.4**	11.4	0	2.2

Although the research on the nature of communication reveals that speakers do not ask or respond to the questions or information which they know in advance (Spada & Fröhlich, 1995), the results of this study illustrate that teacher's speech consists most frequently of pseudo requests (questions to which she already knows the answer) (63.9%; 630 questions out of 986). Correspondingly, the student's speech provides predictable information (responses known to the questioner) (86.4%; 1346 responses out of 1558).

According to Spada and Fröhlich (1995), one of the features of communicative discourse is genuine questions in which the answers are not known in advance. However, as the results in Table 2 show, the teacher asks very few genuine questions (9.8%; 97 requests out of 986). Therefore, contrary to general communicative language teaching, there is a kind of deficiency in terms of real authentic communication in this classroom. Not requesting genuine questions also does not allow students to give unpredictable information. Therefore, those students cannot reflect their understanding and be stimulated in their thinking; they only try to respond to questions correctly.

Sustained speech

The third category of the COLT observation scheme is *sustained speech*, which measures the extent to which speakers engage in discourse or restrict their utterances into one sentence, clause or word. Sustained speech is separated to three sub-major categories: *Ultra-minimal, Minimal* and *Sustained*. The first sub-major category, ultra-minimal is used for only student's turns which consist of one or two-word speech fragments. Furthermore, minimal speech occurs when teacher and students' turns consist of more than one or two words, long phrases, one or two main clauses or sentences. Finally, sustained speech is applied if the teacher and students' turns include at least three main clauses. Table 3 shows the number of teacher's or students' speech that was ultra-minimal, minimal or sustained.

Table 3
Sustained speech used during teacher and student interactions

	Teacher verbal interaction		Student verbal interaction		
Sustained speech	Minimal	Sustained	Ultra-minimal	Minimal	Sustained
f	1054	549	1157	419	22
%	**65.8**	34.2	**72.4**	26.2	1.4

The results demonstrate that the majority of the teacher's speech showed characteristics of minimal speech (65.8%). Moreover, since students provide predictable information in one word or two words, students' talk is also characterized ultra-minimal in nature (72.4%; 1157 speech out of 1598). As a result, students have rare opportunity to engage in sustained communicative discourse in this content-based English/Mathematics classroom.

Reaction to form speech

The fourth category of the COLT observation scheme is *reaction to form speech.* This category is aimed to differentiate whether teacher and/or students react to *the form* (to the linguistic form such as grammar, vocabulary, pronunciation) or react to *the message* (to the meaning or content of the preceding utterance/s).

In this study, the data were collected from an English-mathematics content-based classroom. Therefore, teacher and students tended to focus on errors in content rather than on grammatical errors throughout the teacher and student verbal interactions as shown in Table 4.

Table 4
Reaction to form speech used during teacher and student interactions

Reaction to form speech	Teacher verbal interaction		Student verbal interaction	
	Form	Message	Form	Message
f	0	1406	0	138
%	0	**100**	0	**100**

This category is coded only when the teacher and/or students react to something previously said. In this study, the students' reactions to messages reveal that they react less frequently (138 utterances) to the teacher's or other students' preceding utterances in contrary to teacher's reactions (1406 utterances) to the students' responses. Despite the difference between the teacher and the students’ utterances, the participants of the study, both the teacher and the students, only reacted to the meaning of the utterances (100%).

Incorporation of student/teacher utterances

The last category of the COLT observation scheme is *incorporation of student/teacher utterances* which refers to the different ways in which teachers and students react to each other's utterances (Spada & Fröhlich, 1995). There are seven sub categories: *correction, repetition, paraphrase, comment, expansion, clarification request,* and *elaboration request.* These categories are coded in combination with other categories under *reaction to form/message*. Therefore, the researcher investigates both major categories simultaneously. Table 5 and Table 6 demonstrate the frequency and percentage of incorporations of students-teachers utterances in the content based English-mathematics classroom in the study.

Table 5
Incorporations of student utterances used during teacher verbal interaction

Incorpor. of student utterances	Corre.	Repetit.	Paraph.	Comm.	Expans.	Clarif. req.	Elabor. req.
f	0	829	116	479	265	100	725
%	0	**33.0**	4.6	19.1	10.5	4.0	28.8

Table 6
Incorporations of teacher utterances used during student verbal interaction

Incorpor. of student/teacher utterances	Corre.	Repetit.	Paraph.	Comm.	Expans.	Clarif. req.	Elabor. req.
f	0	22	0	65	32	24	0
%	0	15.4	0	**45.4**	22.4	16.8	0

The first sub-category, *correction,* is only used for coding errors in form, not errors in content or meaning, in other words, linguistically or grammatically incorrect utterances. As shown in Table 4, there is no reaction to form by either the teacher or the students, so no correction exists in this content-based classroom (see also Table 5 and 6).

The second sub-category, *repetition,* is coded if the teacher or the students repeat full, or partial, preceding utterances of one another without changing the linguistic form. In this study, the teacher uses repetition for approving the accuracy of student's previous response. Although the teacher frequently uses repetition during communicative discourses (33.0%; 829 utterances out of 2514) as shown in Table 5, students repeat teacher's utterances less frequently (15.4%; 22 utterances out of 143) as presented in Table 6.

Paraphrase is the third sub category, which is the reformulation of previous utterances. As shown in Table 5, the teacher in this study occasionally paraphrases the students' responses, while the students never applied paraphrasing to teacher's utterances.

In addition, the students' most frequent reaction (45.4%; 65 utterances out of 143) to teacher's utterances is seen in the fourth sub category, *comment* (Table 6). Comment refers to the response, which is either positive or negative but not correcting, to the preceding utterances. As illustrated in Excerpt C, the teacher comments by saying "Good!" to the student's (Ekin) response.

The fifth sub category of incorporation of students-teacher utterances in the COLT observation scheme is *expansion.* The utterance is coded as expansion if there is any extension of the information provided in a proceeding utterance or addition of information which is related to the previous one (Spada & Fröhlich, 1995). Table 5 demonstrates that the teacher occasionally extends students' utterances related to the content or add new information related to previous content (10.5%; 265 utterances out of 2514) whereas the students often extent their utterances (Table 6) only by considering their own responses (22.4%; 32 utterances out of 143).

Finally, the sixth and seventh sub categories are *clarification request* and *elaboration request*, respectively. Clarification request is applied to the clarification of a previous utterance which is not clearly understood while elaboration request consists of requests for further information related to the previous utterances or for more additional explanations for preceding utterances. As demonstrated in Table 5, the teacher poses an elaboration request after she repeats the student's corresponding response so that after the repetition (33.0% ; 829 utterances out of 2514) the second most frequent incorporation utterances of teacher is the elaboration request (28.8%; 725 utterances out of 2514) rather than clarification request (4%; 100 utterances out of 2514). This is because the teacher often implies elaboration request by repetition through emphasis on repetition word or rising intonation. Contrary to the teacher's, the students' incorporations of teacher or other students' utterances (Table 6) do not consist of any elaboration request (0%) while they often use the clarification request (16.8%; 24 utterances out of 143).

To sum up, firstly, the analysis of communicative discourse revealed that both the teacher and students used only the target/second language (which is English) in this content-based classroom where the medium of instruction was English. Thus, as only the target language was spoken in class (100%), this content-based classroom adhered to the standards to communicative discourse. Secondly, the results of this study demonstrated that the teacher's speech consisted most frequently of pseudo request for information (questions that the teacher knew the answer in advance) (63.9%; 630 questions out of 986). Therefore, as the results clearly showed, the students' speech provided predictable information (response known to the questioner) (86.4%; 1346 responses out of 1558).

Additionally, in contrary to general communicative language teaching, teacher rarely asked genuine questions (answers that were not known in advance) (9.8%; 97 requests out of 986). Hence, the deficiency of genuine request brought about very few unpredictable responses of students. Thirdly, in sustained speech, the teacher's speech showed minimal speech characteristic (more than two word, or sentence) (65.8%) whereas students' talk was characterized as ultra-minimal speech fragment (one or two word) (72.4%) rather than minimal or sustained speech. So, it could be inferred that students had reduced poor opportunity to engage in sustained communicative discourse in this content-based classroom.

Moreover, the teacher reacts to errors only to the content rather than to form (grammar, vocabulary or pronunciation) and students do as well. As neither the teacher nor the students reacts to the form, there is no correction (which is one of the reaction ways to each other's preceding utterances and used only for reaction to form). However, the teacher frequently repeats the student's utterances (33%; 829 utterances out of 2514) for generally approving the accuracy of students' previous response and she sometimes uses these to imply an elaboration request (28.8%) rather than a clarification request (4%). In contrast students' most frequent reaction is to comment (45.4%). Thus, after repetition, the teacher most frequently uses elaboration request and she usually evaluates students' previous answer by a comment (19.1%). The teacher occasionally uses paraphrase, while the students never apply paraphrasing or elaboration request (0%). On the contrary, the students rarely expand on their own ideas to clarify their solution.

In conclusion, the results of these two different analyses indicate that the students have a rare opportunity to engage in sustained speech or to extend their speech even though they are encouraged to participate in mathematical and communicative discourse in this content-based classroom.

CHAPTER 5: DISCUSSION

Introduction

This ethnographic research aimed to examine the culture of a multicultural content-based English/Mathematics classroom in terms of mathematical discourse and communicative discourse. In this chapter, the major findings of this study will be presented by drawing from the relevant literature. After that, based on the findings I will present the implications, and limitations of this study as well as recommendations for further research.

Overview of the study

This study focuses on the culture of a multicultural content-based English/Mathematics classroom at an international school in Turkey. Within the naturalistic framework (Lincoln & Guba, 1985), as a participant observer (Spradley, 1980), ethnographic research was conducted with a selected group of seventh grade students (21 students with diverse nationalities) and an international mathematics teacher (native English speaker) in a multicultural content-based classroom where the medium of instruction is English. Data were collected through audio recordings gathered through observations at least one time a week during one semester of 17 seventh grade lessons by focusing on teacher-student interactions and student-student interactions in their natural settings. Transcripts of those classroom observations, supplemented by the field notes and course materials, provided the main source of data for this study.

The data analysis was conducted through two separate set of analysis methods: qualitative method for the mathematical discourse and descriptive method for the communicative discourse. The characteristics of mathematical discourse were investigated by using method of analytic induction (Bogdan & Biklen, 1992) and then the communicative discourse was analyzed by using Communicative Orientation of Language Teaching (COLT) observation scheme (Spada & Fröhlich, 1995).

Discussion of the major findings

The mathematical discourse on a content-based classroom

The analysis of the culture of a multicultural content-based English/Mathematics classroom in terms of mathematical discourse revealed that the mathematical discourse in the present study had four featured characteristics: use of the language of mathematics; use of strategies, methods/ways of solution and different perspectives; use of mathematical reasoning and mathematical justification; and use of connection between mathematical ideas/concepts and extension in mathematical thinking. These themes resonated with the current research on not only content-based instruction but also mathematical discourse (Streyker & Leaver, 1997; Moschkovich, 1999, 2012).

In this study, the teacher recognized and acted upon a major tenet of the language of mathematics. The teacher of this class gave importance to the accurate word usage in the appropriate content of mathematics and its meaning in the corresponding context rather than their grammar or vocabulary. In other words, students were encouraged to use *language of mathematics*[3] which was not only vocabulary but also the word

[3]Moschokovich (2012) uses the notion "language of mathematics" as "communicative competence is necessary and sufficient for the competent participation in mathematical discourse rather than a list of vocabulary or technical words (pp. 17-18).

usage in a mathematical context (Moschokovich, 2012). Therefore, students could learn new concepts through meaningful content while they developed their language skills which supported the previous research in content-based instruction (CBI) (Heo, 2006; Kranke, 1987; Lightbown, 2014). The teacher *revoiced* (Chapin, O'Connor, & Anderson, 2009) or restated students' responses by using technical terms which facilitate them to comprehend the use of language of mathematics. This approach supported not only the improvement of student's mathematical thinking as well as their language learning but also the teachers' view of teaching mathematics (Blanton, Berenson, & Norwood, 2001; Chapin, O'Connor, & Anderson, 2009). Furthermore, the students made a great effort to use the language of mathematics appropriately through teacher's support, help and engagement. In mathematics instruction for English learners, language should be used as a resource but more than a dictionary and teachers should support English language learners not only in English but also in learning mathematics (Moschkovich, 1999) and this process should happen "by receiving content input in the target language" (Duenas, 2003, p.1). This purpose was satisfied in this content-based classroom of this study. These findings served the purpose of CBI to foster the students "to learn a new language by *using* that language as a real means of communication" (Stryker & Leaver, 1997, p. 3).

Second, the results indicated that different strategies/perspectives or methods of solution were used in this content-based classroom. As stated in the study of at an international school which examined the dynamic nature of mathematics as a cultural product, "mathematics is a dynamic form of knowledge, created by and in different cultures" (Corlu, 2013, p. 78). The teacher of this class facilitated all students to get the correct response while she expected them to use their own manner of solution in terms of various representation models. In this manner, she allowed all students to share and explain their ideas and to discuss different perspectives among the class. The studies conducted in content-based classrooms indicate that students who are taught in a well-organized content-based classroom are more likely to engage in meaningful communication due to the interaction with more sophisticated individuals while they are learning language so that they become autonomous, and lifelong learners (Lantolf & Pavlenko, 1995; Stryker & Leaver, 1997).

In this context, the teacher of this content-based classroom facilitated the students to become autonomous and lifelong learners, for example by encouraging them to devise a plan and decide which method or strategy before working out the problems as outlined in Polya's problem solving steps (Polya, 1845). This approach also enabled the teacher to evaluate whether the students understand the given problem and whether they have a plan to solve it. Moreover, it provided students who do not have a strategy or method of solution, to realize several strategies that can be used, as problem solving enables students to deal with new and unfamiliar tasks even if the possible solution methods are not known (Polya, 1845).

Allowing students to share their thoughts without judgment also increased the number and variety of responses which improves the students' mathematical thinking. According to the fieldwork of Campbell (1992) on public school content-ESL teachers working with Southeast Asian refugees, more than language and content needs to be considered for teachers to develop critical elements of instructional materials and activities presented in mathematics classes where English was the only language of instruction. Campbell's (1992) work emphasizes the importance of "the relationship among language, life experiences, culture, and instructional content" (p. 4) in the classes where the students are from a variety of language groups and are taught English through a focus on teaching content. Similarly, the results of this study showed that the teacher encouraged students to elicit their answers in such a way that they learned not only how the others think about the problems but also multiple ways to think about and solve problems as there are infinitely many solution methods or strategies used in mathematics.

Although students in this content-based classroom were encouraged to explore and find their own solution methods or representations of solution as well as the result of a computation, several research studies state that the teacher should pose open-ended questions more frequently than simple, closed or leading questions (Brahier, 2010; Martino & Maher, 1999; Piccolo et al., 2008). Researchers examining questioning strategies (e.g., Brahier, 2010; Christensen, 1991) suggested that discourse should be based on taxonomies, such as Bloom's, and that open-ended questions should be applied for provoking a discussion atmosphere, improving weak discussions, facilitating learning, and gaining insight into children's thinking as well as fostering curiosity and inquiry (Piccolo et al., 2008; Ralph, 1999a, 1999b; Stenmark, 1991). According to NCTM Standards 5, (1991; 2007) teachers should raise open-ended questions in order not to limit the diversity of responses and ensure a productive mathematical discourse. Brahier (2010) and Martino and Maher (1999) emphasized another significant point: open-ended questions let students explain their solution in several different ways although these questions might have one correct response. However, in this study the students had limited opportunities to make detailed statements.

Third, this study showed that the use of mathematical reasoning and justification was provided in this content-based classroom. Several research studies revealed that productive mathematical discourse can facilitate the development of students' mathematical thinking and reasoning skills (Davis, 1997; Kazemi, 1998; Knuth & Peressini, 2001; Lo & Wheatley, 1994; Martino & Maher, 1999; NCTM, 1991; 1996; 2007; Pirie, 1996; White, 2003). In this study, the teacher enabled students to critically analyze their answers, or sometimes their methods of solution and to explore where they made errors and then to correct their own mistakes by themselves. To give more opportunities for students to participate in mathematical discourse, the teacher of this class supported students to explore and make sense of their strategy or to generate new ideas by posing a new question or an elaborating question instead of providing information or demonstrating her method of solution or her perspective. Properly managed classroom discourse enables students to focus on sense making and reasoning; it also enables teachers to criticize students' understanding and to foster conceptual understanding and mathematical thinking (Boaler & Greeno, 2000; Kazemi, 1998; Piccolo et al., 2008; Simon & Blume, 1996; White, 2003). Therefore, as Ball (1993) claims productive mathematical discourse should be used in mathematics education because it enriches student in doing mathematics, conjecturing, reasoning and defending one's ideas, in addition to learning mathematics.

In order to inquire whether the solution steps would lead the student to the correct result, the teacher encouraged students to investigate why such a result appears during the corresponding solution step. For example, Chapin, O'Connor and Anderson (2009) state that "teacher's questioning techniques are very much related to increasing students' achievement so that higher order questions (e.g., those that ask students to apply, analyze and reasoning) produce more learning than questions that focus simply on recall for information" (p. 41). In this study, the teacher wanted her students to be responsible for judging not only their own answers but also the answers and ideas of others. Therefore, the teacher has a crucial role to guide students to develop their reasoning skills by asking them to clarify and justify their ideas orally and in writing (NCTM, 1991). Piccolo, et al., (2008) stated:

> The potential for rich, meaningful discourse can occur when teachers ask questions that resemble the logical thinking process for solving a problem (explanation), when the teacher engages students by asking if is there is another way to solve the problem (justification), or when the teacher asks questions that extend beyond rote memorization. (p. 375)

Thus, in this content-based classroom, although students were quite eager to engage in reasoning or to present diverse perspectives during mathematical discourse as well as to justify their thinking with an acceptable evidence, the teacher did not provide rich opportunities for them by posing critical questions.

The last major finding of the analysis of the culture of content-based English/Mathematics classroom demonstrated how the students' mathematical competence was enriched and reinforced by setting up a context in which the students discover the connection between mathematical concepts and made inference and then extend their mathematical knowledge. In this study, the students were expected to make connection between mathematical concepts and apply one property to another. This was ensured in this classroom by the teacher's challenging and advancing questions to stimulate further thought as Martino and Maher (1999) suggest. Well-prepared questions scaffold students' engagement with the task and the nature of the classroom environment including ensuring students to get the correct answer of the question, and give students a chance to learn high-level mathematics (Boaler & Brodie, 2004; Kazemi & Stipek, 2001; Smith, 2000; Stein, Remillard, & Smith, 2007; Wood, Cobb, & Yackel, 1991). According to the COLT categories, in order to describe a class as more communicatively oriented, in that class, the teacher spends more time focusing on meaning and group work interaction (Spada & Fröhlich, 1995). If those conditions are satisfied, then the students learn and do mathematics by participating in mathematical discourse so that in the present study working in groups might be beneficial to increase the participation.

The communicative discourse on a content-based classroom

After investigating the culture of a content-based English/Mathematics classroom in terms of mathematical discourse, the researcher also descriptively analyzed the transcripts with respect to communicative discourse using the *Communicative Orientation of Language Teaching (COLT): An observation scheme* (Spada & Fröhlich, 1995). The first category of the COLT observation scheme is the *use of target language*. The results revealed that the teacher and students used the target/second language-English-as the medium of instruction. Thus, this content-based classroom adheres to the standards to communicative discourse because use of the target language is a good indicator of a communicative discourse which is known for facilitating language acquisition (De Graaff, Jan Koopman, Anikina, & Westhoff, 2007).

The second category of the COLT observation scheme, *information gap*, illustrated that teacher's speech consists frequently of pseudo requests and rarely consisted of genuine questions even though the research on communicative discourse claims that the speakers should not pose questions of which they know the answers in advance

(Spada & Fröhlich, 1995). The students in their speech provided predictable information. The deficiency of genuine request brought about only a few unpredictable responses of students. Therefore, it can be inferred that this content-based classroom was insufficient in terms of providing opportunities for students to engage in real authentic communicative discourse because one of the four characteristics of communicative approach of CBI is that the communicative classrooms in which students have to use the language productively in authentic contexts (Brown, 1994).

In the third category of the COLT observation scheme, *sustained speech*, the teacher's speech shows minimal speech. As the students provide predictable information in one word or two words, students' talk was characterized as ultra-minimal in nature rather than minimal or sustained speech. This result implies that the students had poor opportunity to engage in sustained communicative discourse in this content-based English-mathematics classroom contrary to real authentic communicative discourse (Spada & Fröhlich, 1995).

The fourth category of the COLT observation scheme is the *reaction to form/message*. The participants, both the teacher and students, reacted to nothing but the errors in content, rather than in form (grammar, vocabulary or pronunciation). This practice is supported by the theory of communicative competence, that is, language acquisition is much more than knowing the rules of grammar (which is actually language competence) (Brown, 1994; Hymes, 1972; Krashen, 1989). However, the students' reactions (138 utterances) to message of the teacher's or other students' preceding utterances are very few in contrast to teacher's reactions (1406 utterances) to the students' responses.

The last category of the COLT observation scheme is the *incorporations of students/teacher utterances* which involves seven minor categories: *correction, repetition, paraphrase, comment, expansion, clarification request and elaboration request.* As neither the teacher nor the students react to form, there is no correction (which is one of the reaction ways to each other's preceding utterances and used only for reaction to form) in this content-based classroom. However, the teacher frequently uses repetition of student's utterances generally for approving the accuracy of students' previous responses and sometimes for implying an elaboration request or clarification request. Thus, after repetition, the teacher most frequently uses elaboration request and she usually evaluates students' previous answer with a comment. The teacher rarely applies paraphrasing and occasionally uses expansion to add new information related to previous content. In contrast, the students repeat teacher's utterances rarely. Students' most frequently react to the teacher's or other students' utterances by a simple comment; secondly, they expand the ideas; thirdly, they use the clarification request while they never apply paraphrasing or elaboration request. Although it is advantageous for communicative discourse from the view of students, it seems to be insufficient for students. If the number of utterances of the teacher and students were compared, students have only a few chances to react to teacher's or others' utterances can be inferred. However, in communicatively oriented classrooms, teachers spend more time focusing on meaning and group work interaction and students use the language in creative and unrestricted ways with the great participation in the negotiation of topics and tasks (Spada & Fröhlich, 1995).

Conclusion

The analysis of mathematical discourse indicates that in this content-based classroom, mathematical discourse is productive in terms of encouraging students to use the language of mathematics; strategies, solution methods and different perspectives; mathematical reasoning and mathematical justification; and connection between mathematical ideas/concepts and extension in mathematical thinking. As a result, the students in this classroom do and learn mathematics by participating in mathematical discourse. Yet, the teacher frequently poses a series of simple, closed and leading questions rather than open-ended and advanced ones so that the students are rarely afforded opportunities to extend their speech. However, the communicative discourse has both strengths and weaknesses. The strengths are that both the teacher and students used only the target/second language (which is English) in this content-based classroom which serves the standards of communicative discourse. Moreover, the teacher and students react to errors only in the content rather than on form (grammar, vocabulary or pronunciation). Nevertheless, the weaknesses are greater than the strengths. The observed level of discourse does not encourage real communication.

In conclusion, the teacher-students interaction is appropriate in terms of teaching mathematics but inadequate for improving learner's English. On the contrary, since this is a content-based classroom where English is only the medium of instruction it carries features of mathematical discourse. Yet, in terms of communication, the teacher tends to ask questions to which she already knows the answers, and this restricts the variety of language forms that students can produce (Spada & Fröhlich, 1995). In a content-based classroom, mathematics instruction should aim to encourage English learner students to participate in communicative discourse because they are not only learning mathematics but also they are learning English. In this sense, the teacher should give equal weight to both mathematical reasoning and language development of English learners (Moschkovich, 1999).

Implication of practice

This study will contribute students, who are learning mathematics in a content-based English-mathematics classroom, for using the language of mathematics more effectively while doing mathematics. Furthermore, the study can be a guided tool for not only teachers as a means of self-analysis but also teacher educators in terms of noticing how they can support student-teachers. Also, for teachers and student-teachers, this study will establish that mathematical and communicative discourse can act as a new model for conducting mathematics lesson plans to enrich students' participation in mathematical and communicative discourses. Therefore, the recommendations are designed to help those interested in the educational experiences of content-based classrooms and extend to make effective teaching strategies in these classrooms as well as regular mathematics and English classrooms.

In the teacher-centered classrooms, students do not learn mathematics effectively because they passively listen to teacher directions so that they cannot be engaged in the learning process (White, 2003). This study highlights the inevitable role of mathematical and communicative discourse in a content-based classroom because students can learn a second language by participating in an extending discourse (Swain & Lapkin, 2000). Due to the attention in the recent years on discourse in content-based classrooms and its importance to student learning mathematics and English simultaneously, teachers and teacher educators from all around the world are finding that they can help children become autonomous learners by increasing their participation in mathematical and commutative discourse in content-based classrooms.

One of the implications of this study is that mathematics instruction in content-based classrooms should be provided through mathematical discourse in order to engage students in mathematical reasoning and to discover important mathematical concepts (Stein, Remillard, & Smith, 2007; Truxaw & DeFranco, 2007). In this framework, teachers should support English language learners not only in learning mathematics but also in learning English by encouraging them to participate in mathematical and communicative discourse not only to acquire technical vocabulary but also the vocabulary usage in a content (Blachowicz & Fisher, 2000; Moschkovich, 1999; 2012). Hence, students can learn both vocabulary and mathematics so the language of mathematics.

Mathematical and communicative discourse play a critical role in prompting learning through doing, thinking, talking, conjecturing, scrutinizing, agreeing, disagreeing about mathematics (e.g., Ball, 1991, 1993; Cobb, Yackel, & Wood, 1993; Lampert, 1990; Nathan & Knuth, 2003) in such a way that if this kind of opportunity is provided to students, that is, if students are actively engaged in classroom discourse, they are likely to be engaged in more meaningful and sustained learning experiences (Walshaw & Anthony, 2008). However, as the discourse is directed by the effective questions raised by the teacher, the teacher should pose clear but critical questions with artistry which emphasizes "how specific key questions to be asked to the students should be written in advance"..."because the way that teachers ask questions determines whether students actively engage in a discussion or shy away from it" (Brahier, 2010, p.193). Hence, in order not to limit the diversity of responses and for a discourse to be productive, teacher should ask open-ended questions. Therefore, asking open-ended challenging questions is not sufficient to bring about change in students' mathematical and communicative competence in a content-based English/Mathematics classroom.

For teacher educators, this study can be a good source in terms of noticing how they can provide the essential scaffolding for student-teachers during their training in order to make sense of and learn from the type of classroom which characterize their teaching practices (White, 2003). Moreover, by analyzing classroom discourse in a content-based classroom, the educators can get a more authentic picture of a qualified teacher's models of teaching than the secondary sources provide.

Implication for further research

This study addresses the areas of mathematical and communicative discourse in a content-based English/Mathematics classroom. In literature there is a wide range of meanings and uses of the term discourse but these meanings are implicit in the analyses of mathematical and communicative discourse separately or both. Although the majority of the works tending to isolate discourse from the mathematics or language instructions, this study would advance not only in defining those terms, mathematical and communicative discourse, but also in describing their relation to one another in terms of content-based classrooms.

Although the issue of whether secondary level students can participate in mathematical discourse efficiently in mathematics lessons is highly debatable in education; studies failed to examine the culture of a content-based classroom in regards to mathematical and communicative discourse in these classrooms. Even though there are several international schools applying CBI in Turkey, almost no research is conducted about the issue of mathematical and communicative discourse in a content-based classroom. Therefore, this study will be of interest for not only to mathematics education researchers, but also to the broader scientific community concerned with the issues related to mathematical discourse and communicative discourse in content-based instruction. However, knowledge about mathematical and communicative discourse in content-based classrooms is very rudimentary. More research on mathematical and communicative discourse is needed to provide more evidence of the practices of successful teachers of diverse students in content-based classrooms.

Limitations

The findings of this ethnographic study can be generalized to students who are educated in similar context. However, the researcher did not conduct interviews with the teachers or the students to see how they make sense of these two discourses. Additionally, this was an international school and it cannot be known how different a mathematical discourse is in L1 or whether it would reveal similar features. Finally, one of the limitations of this study results from not knowing the extent to which the characteristics of the discourse in the present study is influenced by the content-based instruction or if it would be the same in a regular mathematics classroom.

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APPENDICIES

Appendix A: Communicative orientation of language teaching (COLT) observation scheme: Part B

	TEACHER VERBAL INTERACTION																	STUDENT VERBAL INTERACTION																					
	Target Language		Information gap Giving Inf		Request int		Sustained speech		Reaction to form/speec		Incorporation of student utterances								Target language		Information gap Giving info		Reaquest inf		Sustained Speech			Form restriction			Reaction to form/messa		Incorporation of student/teacher utterances						
Task	L1	L2	Predictable info	Unpredictable info	Pseudo request	Genuine request	Minimal	Sustained	Form	Message	Correction	Repetition	Paraphase	Comment	Expansion	Clarification request	Elaboration request	Discourse initation	L1	L2	Predictable info	Unpredictable info	Pseudo request	Genuine request	Ultra-minimal	Minimal	Sustained	Choral	Restricted	Unrestricted	Form	Message	Correction	Repetition	Paraphase	Comment	Expansion	Clarif. Request	Elab. Request
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40

Appendix B: An example of analysis of communicative discourse in COLT observation scheme

	TEACHER VERBAL INTERACTION																	STUDENT VERBAL INTERACTION																	
	Target Language		Information gap				Sustained speech		Reaction to form/speec		Incorporation of student utterances							Target language		Information gap				Sustained Speech			Reaction to form/mess		Incorporation of student/teacher utterances						
			Giving Info		Request int															Giving info		Reaquest inf													
Interaction	L1	L2	Predict	Unpredict	Pseudo requ.	Genuine requ.	Minimal	Sustained	Form	Message	Correction	Repetition	Paraphase	Comment	Expansion	Clarif. Request	Elab. Request	L1	L2	Predict	Unpredict	Pseudo request	Genuine request	Ultra-minimal	Minimal	Sustained	Form	Message	Correction	Repetition	Paraphase	Comment	Expansion	Clarif. Request	Elab. Request
T&MAYA		1	1		1			1											1	1					1										
T&EKIN		1			1			1		1			1						1	1					1										
T&GANDHI		8			1		6	2		8		4		3	1	3	4		8	7	1			7	1			1						1	
T&MAYA		1			1			1		1		1			1				1	1					1										
T&DENIZ		3			1		2	1		3		1			1	1	1		3	3					2	1		2		1			1		
T&ANTHONY		1			1			1											1	1				1											
T&CLASS		1			1		1			1		1							1	1				1											
T&ANTHONY		1		1				1		1				1	1		1		1	1					1										
T&CLASS		3			1		1	2		3		1		2	1		2		3	3				3											
T&ONAT		3		1	1		3			3		2		2			1		3	3				2	1										
T&MARTIN		1		1		1		1		1		1		1	1				1	1					1										
T&MICHELLE		3	1	1	1	1		3		2			1	1	1	2			3	2	1				3			2				1	1		
T&CLASS		1			1			1		1			1	1					1	1				1											
T&VERA		1		1	1			1		1				1					1	1				1											
T&MEHMET		2			1		1	1		2		1		2			1		2	2				1	1			1					1		
T&EZGİ		1			1			1				1		1	1				1	1					1										

Appendix C: The frequency and percentage of teacher/verbal interactions according to COLT observation scheme

	TEACHER VERBAL INTERACTION																	STUDENT VERBAL INTERACTION																			
	Target Language		Information gap				Sustained speech		Reaction to form/speech		Incorporation of student utterances							Target language		Information gap				Sustained Speech			Form restriction		Reaction to form/messag		Incorporation of student/teacher utterances						
			Giving Info		Request info															Giving info		Reaquest i															
Task	L1	L2	Predict	Unpredict	Pseudo requ.	Genuine requ	Minimal	Sustained	Form	Message	Correction	Repetition	Paraphase	Comment	Expansion	Clarif. Request	Elab. Request	L1	L2	Predict	Unpredict	Pseudo reques	Genuine requ	Ultra-minimal	Minimal	Sustained	Choral	Restricted	Form	Message	Correction	Repetition	Paraphase	Comment	Expansion	Clarif. Reques	Elab. Request
Lesson 1	0	178	9	8	69	6	120	58	0	169	0	54	19	80	26	17	84	0	180	160	18	0	1	111	67	3	25	145	0	31	0	7	0	9	9	6	0
Lesson 2 & 3	0	188	10	16	74	4	101	79	0	161	0	93	11	56	34	15	90	0	182	165	14	0	5	131	50	1	25	157	0	18	0	6	0	6	3	4	0
Lesson 4 & 5	0	135	7	7	55	2	103	32	0	111	0	58	6	44	19	12	50	0	134	112	17	0	4	109	25	0	29	105	0	10	0	0	0	6	3	2	0
Lesson 6 & 7	0	140	6	15	44	6	93	45	0	128	0	76	10	37	26	8	74	0	140	111	24	0	2	102	29	3	11	129	0	6	0	3	0	1	2	1	0
Lesson 8 & 9	0	240	9	48	84	14	172	70	0	205	0	155	10	48	34	13	122	0	241	200	24	0	4	177	52	4	46	195	0	7	0	1	0	4	1	1	0
Lesson 10	0	82	4	13	30	8	63	18	0	66	0	40	2	28	10	6	38	0	83	65	14	0	0	63	21	0	11	72	0	6	0	1	0	1	3	0	0
Lesson 11	0	132	4	30	60	14	80	51	0	98	0	62	11	23	19	2	46	0	122	100	16	0	7	94	29	3	25	97	0	8	0	2	0	3	1	3	0
Lesson 12 &	0	194	5	23	79	14	133	58	0	169	0	106	20	57	25	10	79	0	200	170	14	0	2	148	43	3	27	173	0	19	0	2	0	9	4	4	0
Lesson 14	0	123	7	7	45	11	78	43	0	112	0	61	12	32	25	7	59	0	128	103	16	0	5	80	44	4	10	118	0	10	0	0	0	5	3	2	0
Lesson 15	0	88	5	6	31	13	50	37	0	83	0	50	4	47	13	6	35	0	89	61	12	0	1	55	33	1	12	77	0	17	0	0	0	16	2	1	0
lesson 16 & 1	0	117	10	10	59	5	61	58	0	104	0	74	11	27	34	4	48	0	116	99	9	0	3	87	26	0	13	103	0	6	0	0	0	5	1	0	0
FREQUENCY	0	1617	76	183	630	97	1054	549	0	1406	0	829	116	479	265	100	725	0	1615	1346	178	0	34	1157	419	22	234	1371	0	138	0	22	0	65	32	24	0
PERCENTAGE	0%	100%	7.7%	18.6%	63.9%	9.8%	65.8%	34.2%	0%	100%	0%	33%	4.6%	19.1%	10.5%	4%	28.8%	0%	100%	86.4%	11.4%	0%	2.2%	72.4%	26.2%	1.4%	14.6%	85.4%	0%	100%	0%	15.4%	0%	45.4%	22.4%	16.8%	0%