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A Suggestion of a Framework: Conceptualization of the Factors That Affect Technology Integration in Mathematics Education

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ABSTRACT

The aim of this study is to identify the main factors that affected the process of technology integration in mathematics education. The methodological approach taken in this study is a structured grounded theory. The participants of the study included two secondary-school mathematics teachers, four students selected by the teachers, and two school administrators who were responsible for technology implementation. The data collection tools included two semi-structured interview forms based on a literature review, whose pilot studies were conducted, to identify the opinions of teachers, students and administrators separately. The data analysis method of the study was the constant comparative method that requires to collect data constantly and create codes and categories suggested by the grounded theory. For the analysis of the data, the qualitative data analysis software, MAXQDA 2020, was employed. Based on the findings of the study the factors that affected the process of technology integration in mathematics education were examined as teacher-driven and non-teacher driven factors. The results of the study highlighted that teachers were highly effective in the integration process. Therefore, 20 factors that affected the teachers were identified. These factors included perception of technology, technological awareness, self-confidence, planning and technological materials; and 9 factors that were related to non-teacher-driven aspects including physical conditions, administrative support, student readiness, economic situation, mathematics curriculum and mathematics curriculum approach. These factors were associated with each other, and a framework related to the factors that affected technology integration in mathematics education was suggested.

Keywords: technology integration, mathematics education, mathematics teachers, grounded theory, factors, instructional technology

INTRODUCTION

The technological advances of the 21st century and Industry 4.0 technologies and their impacts have altered the world and social structures. Education systems and schools have also affected from this rapid change. Schools are the keystones of society, and this fact has led to the idea of Education 4.0 and the emergence of innovative study environments and styles within the ongoing digital transformation (Durmus, 2019). The importance of adopting existed digital technologies and enhancing their use to improve students' future professional lives have gained more significance in recent years. Therefore, individuals with strong skills in technology integration have an essential role to conform the high standards of the education system.

The concept of technology in the context of education has been first suggested by Finn (1962) under the concept of "instructional technology". Instructional technology refers to media that emerged as a result of the revolution of communication technologies such as television, films, overhead projectors, computers and other items of "hardware and software" which can be used for instructional purposes alongside the teacher-based instruction methods, textbook and blackboard (Commission on Instructional Technology, 1970). The inclusion of technology in education has led to the introduction of different concepts in time such as Educational Technologies, Information Technologies, and Information and Communication Technologies. The last step of this process is technology integration. International Society for Technology in Education [ISTE] (2000) defines technology integration as the "infusion of technology as a tool to enhance the learning in a content area or multidisciplinary setting and to make technology an integral part of how the classroom functions-as accessible as all other classroom tools". National Center for Education Statistics [NCES] (2002) defines technology integration as the "incorporation of technology resources and technology-based practices into the daily routines, work, and management of schools". According to Wachira & Keengwe (2011) technology integration means incorporating technology and technology-based practices into all aspects of teaching and learning and incorporating appropriate technology in the assessment of learning outcomes and lessons. Based on these opinions, it is argued that technology integration does not have a single definition or procedure (Koehler & Mishra, 2009; Ozmen, Kocak-Usluel, & Celen, 2014).

Recent research studies tend to stress the selection of appropriate technologies, their use and integration of these technologies into lessons (Bhasin, 2012; Haslaman, Kuskaya-Mumcu, & Kocak-Usluel, 2008; Mischra & Koehler, 2006, 2009; National Council of Teachers of Mathematics [NCTM], 2008; Tabach, 2011; Wang & Woo, 2007). Thus, the literature suggested a number of technology integration models such as Technological Pedagogical Content Knowledge-TPCK, Technological Acceptance Model-TAM. These models address various dimensions of technology integration such as teacher acceptance, teacher knowledge, teacher will, and belief.

Technology Integration in Mathematics Education

The integration of technology in mathematics education is one of the most effective ways of enabling students to interpret mathematical concepts. NCTM (2008) highlights technology as one of the six principles of mathematics education. The use of an appropriate technology provides an opportunity for students to enhance their interpretation and focus on problem-solving and reasoning (NCTM, 2008). Technology also helps students to improve their mathematical thinking paths (Keong, Horani & Daniel, 2005), increases the quality and quantity of the realistic mathematical studies, and enhances their mathematics-related ideas (Wachira & Keengwe, 2011). Furthermore, technology serves as an instrument that saves time, and enhances, and focalizes mathematical activities (Dreyfus, 1994). According to Sivakova, Kochoska, Ristevska, and Gramatkovski (2017), in the context of mathematics education, Information and Communications Technologies (ICTs) are used for problem-solving, practicing numerical skills and exploring relationships. Technology-based mathematics education includes many solutions realized via modern calculators (Trouche & Drijvers, 2010), local computers and networks that allow communication (Haapasalo, 2007). These solutions include computer algebra systems (Artigue, 2002), dynamic geometry software (DGS) and dynamic and statistics software (DSS), spreadsheet drawing sheets (Harris & Sullivan, 2000), online software databases, online discussion platforms (Wachira & Keengwe, 2011), Web 2.0 tools, online experiences in digital learning content, digital portfolios, online libraries that include other learning objects and teaching materials, Learning Management System-LMS and visual tools for three-dimensional environments (Haapasalo, 2007). Furthermore, Drijvers (2020) pointed out that there is a need for software programs in mathematical environments that are prepared by teachers and software developers collaboratively. In this context, new technologies are commonly used in mathematics education and have become diversified within time.

In mathematics education curriculums, there are major challenges regarding ICT applications and opportunities (Sivakova et al., 2017). In Turkey, the Ministry of National Education (MoNE) had initiated the FATIH Project (or Movement to Increase Opportunities and Technology) intending to provide mobile education in 2012. In the scope of the project, EIN (Education Informatics Network) was built to provide online contents. Also, trainings were provided to teachers, interactive whiteboards with internet connection were set in classrooms and tablet computers were provided to students (MoNE, 2018a). In this process, teachers were expected to improve their technological competencies and incorporate technology into their teaching methods. In this sense, the competencies provided under the MoNE Secondary School Mathematics curriculum (MoNE, 2018b) included the concepts of "competencies in science and technology" and "digital competencies". Furthermore, the explanation section of the learning outcomes stated that "dynamic mathematical software" and "information communication technologies" should be used. In addition, some of the activities included in the textbooks provided by MoNE were made with a suggestion to use a graphic design program (Aydın, Camus, & Kaya, 2018), and this suggestion offered an opportunity for mathematics teachers to create learning environments enriched by technology.

Factors that Affect Technology Integration

Technology integration is a process that can be affected by various factors (Inan & Lowther, 2010), and this situation brings about the diversification of the affecting factors. The literature review showed that several classifications have been made on this subject, and the research studies have been conducted on the issue. The study conducted by Ertmer (1999) drew attention in the context of the relevant literature. Ertmer (1999), and Snoeyink and Ertmer (2001) distinguished technology integration as primary-external barriers and secondary-internal barriers. Primary barriers referred to barriers related to resources such as lack of resources, lack of technical support, and lack of confidence in using the equipment; and the secondary barriers referred to internal barriers such as culture, beliefs, and attitudes (Snoeyink & Ertmer, 2001). The following studies included lack of education and time to the primary barriers (Ertmer, Ottenbreit-Leftwich, & York, 2006; Kilinc, Tarman, & Aydin, 2018); motivation, personal beliefs about computers, pedagogical beliefs, and existing practices were included in secondary barriers (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Mueller, Wood, Willoughby, Ross, & Specht, 2008).

Different categories have been generated regarding the barriers/factors that affect technology integration. Hew and Bush (2007) grouped these barriers in six categories: Resources, knowledge and skills, attitudes, and beliefs, the culture of evaluation and content knowledge. Similarly, Groff and Mouza (2008) examined the factors that affect technology integration under six components including politics, school, teacher, technology-based projects, student, and technology itself. Also, lack of time (Bauer & Kenton, 2005; Dvorak & Buchanan, 2002; Wachira & Keengwe, 2011), lack of technical support (Erduran & Ince, 2018), high costs (Dvorak & Buchanan, 2002; Ertmer, 2005; Wachira & Keengwe, 2011), and concerns of teachers (Zbiek & Hollebrands, 2008) were also identified as factors that play a role in technology integration. Furthermore, teachers' technological knowledge (Goos, 2005; Koehler & Mishra, 2009; Pierce & Stacey, 2013), pedagogical knowledge (Koehler & Mishra, 2009; Washira & Keengwe, 2011), content knowledge (Koehler & Mishra, 2009), and at the same time combination of these knowledge types (Goos, 2005; Koehler & Mishra, 2009; Washira & Keengwe, 2011) were considered as effective factors in this process. Apart from these studies, the factors that affect technology acceptance are identified as a perceived benefit, perceived easiness of use (Venkatesh & Davis, 1996), voluntariness, experience (Venkatesh & Bala, 2008), and self-confidence (Van Baraak, 2001).

The review of the studies conducted in Turkey on the literature of technology integration highlighted the study conducted by Yildirim (2007) which revealed that overcrowded classrooms, insufficient vocational training programs, lack of technical and pedagogical support on time, inflexible school curriculum, lack of strong leadership and lack of cooperation among teachers affected technology integration process negatively in Turkey. Gunuc (2017) identified the factors that affected technology integration as sociocultural structure, technological infrastructure and resources, parent, student, teacher, school administration, and politics. Furthermore, Tosuntas, Cubukcu, and Inci (2019) synthesized the concepts of Hew and Brush (2007) and Belland (2009) explained the factors that affect technology integration under seven components including resources, knowledge and skills, institute, attitudes and behaviours, assessment and content knowledge, habitus (a teachers' dispositions emerging from a set of learning experiences). In addition to these studies, insufficient technology-based instructions (Kılınc et al., 2018) and limited access to the internet (Korkmaz & Avci, 2016) were identified as factors that played a role in the technology integration process. The literature review showed that these factors alter in time, interpreted in different ways in different countries.

Purpose and Significance

Identification of the factors that affect mathematics teacher's technology integration in lessons has a potential to pave the way for the technological innovations and transformations in preservice and in-service education of teachers, schools and education systems, and therefore, it has great importance for educational managers and decision-makers at all levels (Holznogel, 2005; Kimble, 1999). Many studies argued that the burden of using and integrating technology in lessons falls to teachers as well (Ertmer, 1999; Koehler & Mishra, 2009). In this case, realizing technology integration via teachers leads to viewing the process from a one-dimensional perspective. According to the report published by the British Educational Communications and Technology Agency [BECTA] (2004), there are factors related to the school that restricts the use of technology, in addition to the teacher factor. There is a need to abandon the narrow approach that puts the teacher in the centre and adopt a perspective to view the issue from a wider perspective to identify the factors that support and hamper the performance of teachers.

The literature review showed that research studies related to technology-based teaching have been continued for many years, and the focus of these studies has been mainly put on teacher knowledge, teacher attitude, perception, and particularly on the TPACK model. Furthermore, there has been a dominant view stressing that technology integration has not been fully accomplished (Bauer & Kenton, 2005; Hew & Brush, 2007; Inan & Lowther, 2010). Elaboration, and conceptualization of the factors that affect the integration process were highlighted as important steps to understand the crux of the problem and enable effective technology integration in mathematics education (Straub, 2009). Because, similar to a muted or dampened note in a symphony that disturbs the harmony, and melody, there is a need to clarify factors that contribute to the process of technology integration. Instructional technology studies in Turkey are generally in the field of social studies education and computer and instructional technologies (Gunuc, 2017; Kilinc, Tarman, & Aydin, 2018; Korkmaz & Avci, 2016; Tosuntas, Cubukcu & Inci, 2019; Yildirim, 2007). In Turkey, there is no such suggestion about factors that contribute to the process of technology integration regarding mathematics education. Thus, there is a definite need for a study that addresses such concerns. The results of the study are expected to provide important hints for researchers, educators, teachers, and contribute to the professional development and improvements of mathematics teachers. In this context, the purpose of the study is to identify the factors that affect Turkish mathematics teachers' technology integration practices conceptualize these factors and provide a framework to be included in the literature. For this purpose, this study aimed to address the following research question: "What are the factors that affect Turkish mathematics teachers' technology integration practice?".

METHOD

Research Method

A Grounded Theory research design was chosen as the research method. Grounded Theory is a method that allows producing or exploring the abstract analytical scheme of a phenomenon related to a theory or situation based on experiences or perceptions of participants (Creswell, 2013; Strauss & Corbin, 1998). Furthermore, Charmaz (2015) indicated that theoretical interpretation is an interpretable portrait of the world that is examined. The Grounded Theory method was chosen since the theorizing approach is the most effective paradigm for qualitative research (Denzin, 1997, p. 18; Patton, 2014; cited in p. 124).

Participants

The participants of the study included two mathematics teachers working in an Anatolian High School and a Social Sciences High School located in Izmir and Manisa, respectively; four students selected by each teacher (two students were selected by each teacher) who had different interests regarding technology, and two school administrators who were interested in technology-related aspects in school. The purposive sampling method was used to select the participants. The criterion sampling method which is a type of a purposive sampling method was preferred given that the types of the schools that were selected enabled the use of great numbers of technology tools. Teachers who were selected were capable of using technology in teaching processes with criterion sampling method. For the selection of the students, teachers' opinions were received to choose students who were interested and uninterested in technology, therefore the deviant sampling method suggested by Patton (2014) was used. The main reason for choosing this method was the presumption that each student might have different expectations. Furthermore, the criterion sampling method was chosen since the school administrators who were selected were required to be interested in technology. Firstly, teachers and students were thought as participants. With Charmaz's (2015) suggestion of rich data collections from different data sources, it is thought that administrators would make sense in this study and they may affect teachers' use of technology.

Table 1. Characteristics of Teachers

Teacher	School	Year of Experience	Level of Interest in Technology (1 to 5 years)	Daily Technology Usage Time (Out-of-School)	Faculty	Educational Technologies	Previous Trainings
Teacher Firat	Anatolian High School (AHS)	27	4	2-3 hours	Faculty of Natural Sciences	Starboard, Geogebra, Math type	Use of Interactive Whiteboard
Teacher Ozge	Social Sciences High School (SSHS)	21	4	2 hours	Faculty of Education	Geogebra, Office, Antropi	Geogebra, Computer-based assessment and evaluation, Antropi

Table 2. Characteristics of Students

Students	School	Gender	Grade Level	Level of Interest in Technology (1 to 5 years)	Level of Interest in Mathematics	Daily Technology Usage Time (Out-of-School)	The Way of Following Technological Developments
FS1	AHS	Female	11	3	5	5-6 hours	Smartphone Application
FS2	AHS	Male	10	5	5	1 hour	Smartphone Application
OS1	SSHS	Male	10	5	5	3-4 hours	Social Media
OS2	SSHS	Female	10	3	4	5-6 hours	Random

Table 3. Characteristics of Administrators

	School	Gender	Field	Duty	Year of Experience	Level of Interest in Technology (1 to 5 years)	Presence of a Formative Teacher	Technological Tools Available in the School
FA	AHS	Male	Biology	School Principal	28	3	None	Interactive Whiteboards, Printers, Projection
OA	SSHS	Male	History	School Principal	22	3	Part-Time	Interactive Whiteboards, Computers, Optical Reader, Projection

Participation in the study occurred on a voluntary basis, and the names of the teachers were coded as Teacher Firat and Teacher Ozge. The students of Teacher Firat were coded as FS1 and FS2 and the administrator of Teacher Firat was coded as FA; similarly, the students of Teacher Ozge were coded as OS1 and OS2 and the administrator of Teacher Ozge was coded as OA. **Table 1** shows the characteristics of the teachers, **Table 2** shows the characteristics of the students, **Table 3** shows the characteristics of the administrators. The participants' characteristic features such as level of interest in technology, level of interest in mathematics as seen in **Table 1**, **Table 2**, and **Table 3** were determined through pre-interviews.

Teacher Firat had 27 years of professional experience; was familiar with the tools Starboard, Geogebra, and Math type, and used these tools; was familiar with AutoCAD and Antropi, yet he was not using them. The teacher graduated from the faculty of natural sciences, participated in training programs on the use of interactive whiteboard and Starboard, and had been using a computer for 24 years.

Teacher Ozge had 21 years of professional experience; was familiar with tools such as Geogebra, Office, Antropi, and used these tools. The teacher graduated from the faculty of education and started to pursue a master's degree in the field of mathematics education, and participated in training programs on Geogebra, Computer, assessment and evaluation, book writing, EIN, Flash X, and Antropi. Both of the teachers indicated that they spent 2 to 3 hours on technology-related activities daily.

The first student of Teacher Firat, who was coded as FS1, was an 11th-grade student, female, her level of interest in mathematics was found as 5, and her level of interest in technology was found as 3. The second student of Teacher Firat, who was coded as FS2, was a 10th-grade student, male, his level of interest in mathematics was found as 5, and his level of interest in technology was found as 5.

The first student of Teacher Ozge, who was coded as OS1, was a 10th-grade student, male, his level of interest in mathematics was found as 5, and his level of interest in technology was found as 5. The second student of Teacher Ozge, who was coded as OS2, was a 10th-grade student, female, his level of interest in mathematics was found as 4, and his level of interest in technology was found as 3.

Both of the administrators were school principals. FA was a biology teacher, male, and he had 28 years of working experience; OA was a history teacher, male, and he had 21 years of working experience. The level of interest of both administrators, FA and OA, was determined as 3. The administrators indicated that their level of interest was higher before, yet they marked their level as medium given that technology advances rapidly and they could not catch up with its speed. Both administrators noted that interactive whiteboards were available in every classroom. In addition, both schools provided projectors and printers. OY added that there was an optic reader in the school, yet few teachers use it although the tools were provided to them.

Data Collection Tools

The data collection tools of the study included semi-structured interview forms, observation forms and field interviews. The data collection tools also included two interview forms developed for teachers after the literature review which is a basic for interview questions by taking the opinions of three experts and conducting pilot schemes with the participation of 2 teachers; one interview form developed for students by taking the opinions of three experts and conducting pilot schemes with the participation of 4 students; one interview form developed for administrators by taking the opinions of three experts and conducting pilot schemes with the participation of 2 administrators.

Initial interviews were conducted with Teacher Firat and Teacher Ozge regarding their personal characteristics, technological knowledge in the context of learning situations, and opinions on technology-assisted classroom environments. Afterwards, secondary interviews were conducted to find out what 'use of technology' meant for the teachers, what were the factors affected them or did not affect them in this process.

Interviews were conducted with students about their characteristics, current technological classroom environments, and their opinions on how technology should be used.

Interviews were conducted with administrators about their characteristics, current technological tools provided by their schools, and the teachers' use of technology.

The observation forms that teachers were required to use to follow up with the lessons were developed as a result of the literature review and finalized after receiving the opinions of 3 experts and 8-hours-pilot observations conducted by two mathematics teachers.

The aim of the in-class observations is to find out that teachers acts in classroom and observe the technology use process that they may not mention via interviews. The observation form consisted of information related to the teachers' use of technology during a lesson. The form consists four section: pre-lesson process, introduction process, teaching and learning process and assessment and evaluation process. Also the form included a section that the observer can write down the field interviews and field notes. The teachers were observed for 40 lectures in total divided as 20 lectures for each teacher in the form of both continuous and intermittent observation that changes teachers' technology use situation. This approach was preferred since the teachers' ways of using technology in different subjects were expected to be observed.

The interviews were recorded via a voice recorder with the permission of the participants and each interview lasted between 25-40 minutes. Furthermore, at the end of the observation process, field interviews were conducted for 1 to 5 minutes. For the observations, the criteria suggested by Charmaz (2015) which indicates that observations should be conducted at least for 20 times were taken into consideration. The observations lasted for 40 lecture-hours in total. During the observations, photos were made when necessary with the permission of the teachers. Lastly, considering that combining ethnographic observations and the official reinforcement meetings conducted with participants (field interviews) would be an effective data collection strategy (Charmaz, 2015), field interviews were also included in the process.

Data Analysis Methods

The data analysis method used in the study was the Constant Comparative Data Analysis method that was suggested by the Grounded Theory. Constant Comparative Data analysis is a process that integrates data collection, coding and analysis in theoretical sampling to develop a theory that is integrative, data-focused and provable (Kolb, 2012). Also, MAXQDA 2020 which is a computer-based qualitative data analysis software suggested by Saldana (2019) was employed when coding process.

Process

The data collection process was initiated with the observations. During the observation process, primary interviews with teachers, student interviews, administrator interviews, and secondary teacher interviews were conducted respectively. At the end of each observation, field interviews were conducted with teachers. As required by the Grounded Theory, data collection continued during the data analysis process. After the collection of each data, researchers withdrew from the process temporarily, analysed the particular data, and afterwards, continued to collect data.

The data analysis process consisted of two-coding loops. The first-coding-loop is the preliminary coding which began with the transcription of the interviews, respectively, consisted of in-vivo coding, line by line coding, incident by incident coding, and coding via MAXQDA 2020. At the same time, an additional code-list/notebook was used and groups were created. The coding process of the observations was initiated with the preparation notes created by the researchers. The observation notes did not include the terms used by the participants, therefore the in-vivo coding method was not applied. For the observation notes, line by line coding, incident by incident coding, and MAXQDA coding was applied. A code list/notebook was created for the first-coding-loop.

The second coding loop was the theoretical coding and consisted of steps including focused coding, association, creating categories, and classification. In the meantime, the code-list/notebook was reorganized and Memos (Analytic Codes) were written. In addition, during the data analysis process, free-writings took place constantly. The analysis of the findings was completed with the formation of the scheme. **Table 4** presents the above-mentioned process.

Table 4. Data Analysis Process

<table>
<tr><td colspan="3">1. Loop coding – Preliminary Coding</td><td rowspan="10">Free writing</td></tr>
<tr><td rowspan="4">Grouping</td><td>In-vivo coding (only the interviews)</td><td rowspan="4">Code List-Notebook</td></tr>
<tr><td>Line by line coding</td></tr>
<tr><td>Incident by incident coding</td></tr>
<tr><td>Coding via MAXQDA 2020</td></tr>
<tr><td colspan="3">2. Loop coding – Theoretical Coding</td></tr>
<tr><td rowspan="4">Memo (Analytical Note-Taking)</td><td>Focused Coding</td><td rowspan="4">Reorganization of the Code List-Notebook</td></tr>
<tr><td>Association</td></tr>
<tr><td>Creating Categories</td></tr>
<tr><td>Classification</td></tr>
<tr><td colspan="4">FORMATION OF SCHEMES</td></tr>
</table>

The researchers are experienced in observation and interviewing and currently working on technology-based mathematics education. The interviews took place in the time frame decided by the participant and researchers jointly. During the interviews, the researchers paid strict attention to ensure that they did not influence participants with their questions, gestures, and facial expressions. The researchers also paid attention to avoid making irrelevant comments that might affect participants, were inactive during the observation process and avoided shaping the study in the interpretation processes.

The validity of the data was ensured since the data were collected from different sources and were diverse and profuse. After the collection and analysis of the data, interviews were conducted with participants for member control. As suggested by Creswell (2013) to ensure validity researchers also spent time with the participants outside of the observation setting. Like in every qualitative study, generalization concern may exist. This study contemplates that privatization rather than generalization is a good qualitative research’s differential feature (Greene & Caracelli, 1997).

FINDINGS

While forming the findings of the study, first of all, the transcribed interview documents and the observation notes were coded by the two researchers manually as in-vivo, line-by-line and event-by-event. The documents which consisted of the interview and observation findings were uploaded to MAXQDA. These documents were coded on MAXQDA one by one and the first-level coding (preliminary coding) was completed. On MAXQDA, 1171 codes were created in the first step. Afterward, some of these codes were eliminated since they were not relevant to the research topic. These codes were grouped on MAXQDA using the code list/notebook. In this section, first of all, the codes that were obtained in the preliminary coding and the related-codes were included. Afterward, the sub-categories and categories that were obtained as a result of the theoretical coding were included and the findings section was concluded.

Preliminary Coding

Findings of the teacher interviews

According to teacher interviews, Teacher Firat noted that his level of interest in technology had been changing in time. The findings showed the level of interest of the teacher was highest (5) previously, yet the current level was determined as high (4) given that he could not apply himself into it. On the other hand, the level of interest in technology was determined as high (4) for Teacher Ozge. Furthermore, both of the teachers noted that they felt confident in using technology.

> *“I feel confident on this matter. I think I can handle it in one way or another.” (Teacher Ozge, interview2)*

Teacher Firat indicated that he was often consulted by others, and using technology helped him to earn respect. On the other hand, Teacher Ozge pointed out that this situation was not important.

> *“Teachers consult you on certain issues or they seek your help. They say that I can do it better than them (laughing)” (Teacher Fırat, interview 2)*

> *“There are not many people who can use technology. No one tells me ‘Wow you are great, you are so special’ because I can use technology.” (Teacher Ozge, interview2)*

The findings revealed that both of the teachers had been using the technologies that they were familiar with, and felt confident while using them. The findings also indicated that the teachers preferred to use technologies that they were familiar with or chose similar technologies.

> *“I am focused on technologies that I am familiar with, that I feel more confident in using them. I don’t spend a lot of time for using other tools” (Teacher Ozge, interview2)*

The teachers pointed out that they could learn about using a technological tool in a short time, therefore, it was considered that they got used to using technology. Furthermore, they pointed out that they were disposed to use technology since they spent 2-3 hours every day on technology-related activities.

"I think that I might need time to learn something that I don't know at all, but I also think that I am familiar with the technology." (Teacher Ozge, interview2)

The findings showed that Teacher Ozge was aware of what she could and could not do, while Teacher Firat considered himself competent in any condition. These findings were found noteworthy. The given situations showed that the teachers were aware of their capacities.

"I don't have full knowledge of the programs. I would like to have a better grasp of them. Indeed, I would like to have a better understanding of them.'' (Teacher Ozge, interview 1 and 2)

Teacher Firat and Ozge both said that they should adapt themselves to the advancing technologies. They indicated that they mostly try to learn how to use new tools on their own, and they did not refrain from asking for help when it was needed. Also, Teacher Firat said that he had a curious character, and curiosity has key importance in the first step of using technology. The teacher clearly expressed that he was willing to use technology.

"Of course I am willing to use it. The ones who use technology do that voluntarily." (Teacher Firat, interview1)

The findings also highlighted an important issue as both of the teachers expressed that they had difficulties related to the language of the programs.

"It is one of the most difficult issues for me to handle. Foreign language has always been a challenge for me. But even with little knowledge, it is possible to handle it with little mathematics and language knowledge." (Teacher Firat, interview2)

"I opened the program, and it was all in English, there was nothing in Turkish. Honestly, it was challenging for me." (Teacher Ozge, interview2)

Both of the teachers stressed that a learning environment should be well-equipped and has sufficient physical infrastructure. Teacher Firat added that economic status also played a role in the use of technology.

"The level of technology we want to use depends on the economy of the country. We have many demands. But fulfilling them depends on the economy.'' (Teacher Firat, interview1)

The teachers said that they were using social media platforms related to their fields actively, and in this way, they could improve their content knowledge. Furthermore, they could create original materials, speed up the lectures, save time, enable learning outside of school, encourage students to use technology, and attract students' attention. However, Teacher Ozge also had negative opinions as she pointed out that that technology might cause addiction and deteriorate eyesight. These expressions can be explained under the concept of 'technological awareness'.

"Technology enables us to reach students at different times. My students cannot reach me only if I sleep. We have WhatsApp groups where they can ask their questions related to mathematics. The whole classroom discusses questions there." (Teacher Firat, interview1)

Both of the teachers indicated that they did not prepare particular lecture plans since they were experienced teachers. The teachers considered the materials that they prepared on Starboard or PowerPoint as lecture plans.

"Starboards are my lecture plans. In my first years, also for 15 years, I was stating what I planned to do in the first, second, and third lecture-hour, now I know what to do." (Teacher Firat, interview1)

Teacher Firat stated that he used technology to facilitate the assessment and evaluation process, fulfil the learning needs, explain the parts that students found difficult to understand and attract their attention.

"Let's assume that you draw a shape, in three-dimensional shapes students cannot comprehend the depth. Or you draw a graphic but they cannot determine the orthocentres accurately." (Teacher Firat, interview2)

Teacher Ozge explained that she used technology to catch the attention of students, help them to understand the subjects deeply, and facilitate the assessment and evaluation process.

"Sometimes they ask me about second-degree or third-degree graphics, or how to form the equation of a curve. Geogebra provides direct answers to such questions." (Teacher Ozge, interview1)

Teacher Ozge noted that she adopted an individualistic approach in the learning process and did not prefer to organize group work, and Teacher Firat indicated that he developed instruction methods that were appropriate to the levels of students. Teacher Firat also did not expect students to participate actively in the process of shaping the mathematical knowledge. He continued that he was not sure about enabling students to be active in the mathematics course, yet he set homework that requires students to prepare a presentation for the history of mathematics course and he enabled them to participate actively in this way.

"In the History of Mathematics Course, I asked students to prepare homework about different eras. Mesopotamian era, Egyptian era… They prepared PDFs, slides, videos and they made presentations. The question of how to allow them to

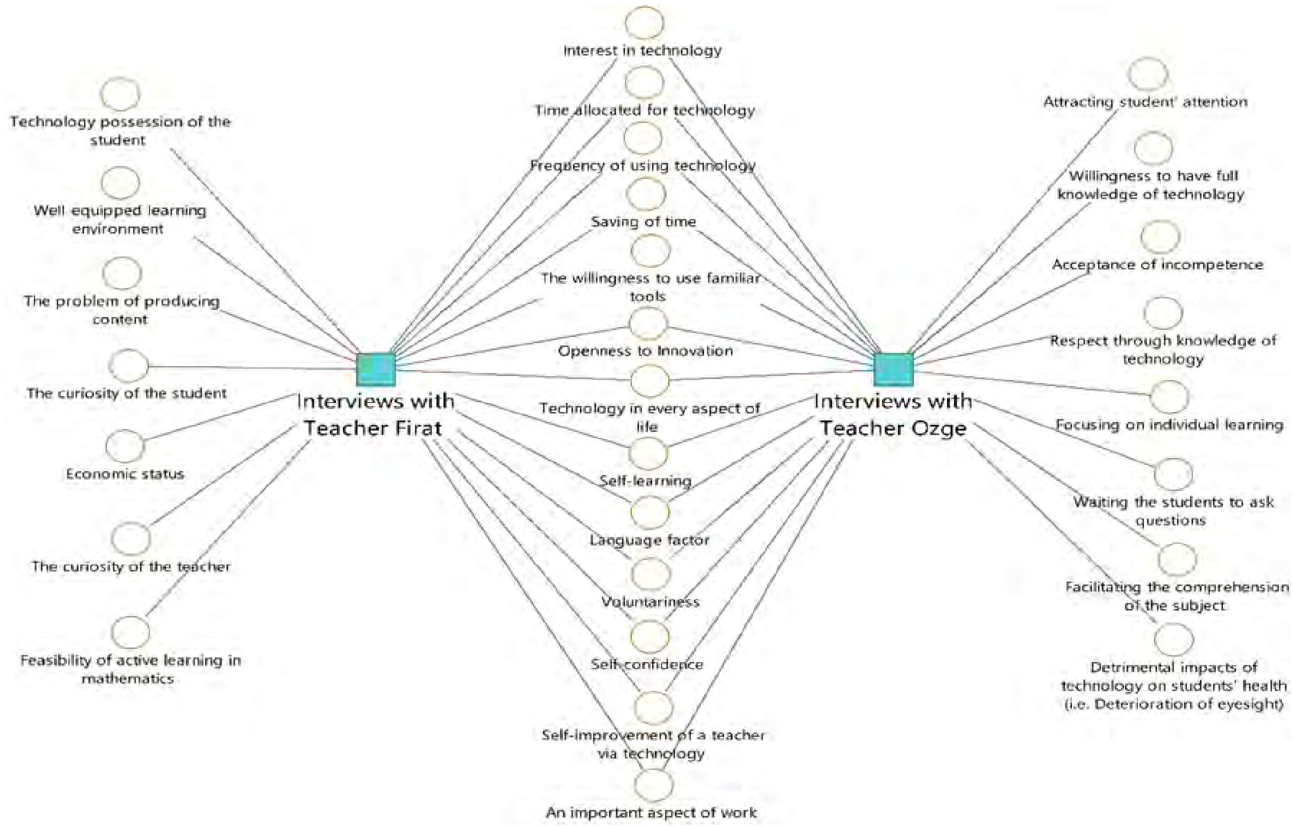

Figure 1. Code Map of the Teacher Interviews

> *participate actively in the other course… The intensity of the current curriculum makes teachers active, not students." (Teacher Firat, interview1)*

For Teacher Firat and Ozge technology was a part of life used by everyone. Also, Teacher Firat indicated that he perceived technology as a medium for entertainment and opportunity, and as a tool to provide education for 7/24. The teacher considered himself as a part of a large family in the context of technology use. The findings revealed that the teacher attributed great meanings to technology. Teacher Ozge stressed that she allocated time to use technology.

> *"Certainly it is in every aspect of our lives. We shouldn't say 'the role of technology' because it's a part of it anyways. It is used for arts, sports…" (Teacher Firat, interview1 and 2)*

Both of the teachers stated that technology is an integral part of their job.

> *"It is an important part of my job. If it wouldn't be, I wouldn't use it in the classroom. If we wouldn't have the technological means in the school, I might put pressure on the administration. Then I would be using projection. I would look for different options." (Teacher Ozge, interview2)*

Teacher Ozge mentioned that she prepared the documents the night before the lecture, collected the documents in her computer, and saved them to be used in the future; on the other hand, Teacher Firat said that he used the material that he prepared, yet he noted that preparing materials could be challenging, and the ready-made materials were not adequate.

> *"It is not possible for a teacher to perform teaching and improve the use of technology. There should be infrastructure, equipment. A teacher cannot provide all. It's very challenging. Also, it is about copy-paste, questions are not produced. The answer key is not completed." (Teacher Firat, interview1)*

Teacher Firat indicated that students need to be curious and conscious about the subjects and there should be a technological infrastructure. Teacher Ozge noted that students should be asking questions continuously, and they should enjoy being at school.

The codes obtained from the interviews conducted with the teachers were presented in **Figure 1**.

Findings of the student interviews

The results of the interviews conducted with the students revealed that the technological tools known and used by four students included smartphone, tablet, computer, and laptop, and only the student OS1 was familiar with Geogebra.

The student OS2 indicated that lectures did fulfil the educational purposes since students could not participate in certain practices, yet the technological tools were used for entertainment purposes. The reason for this situation was stressed as students' lack of access to the internet.

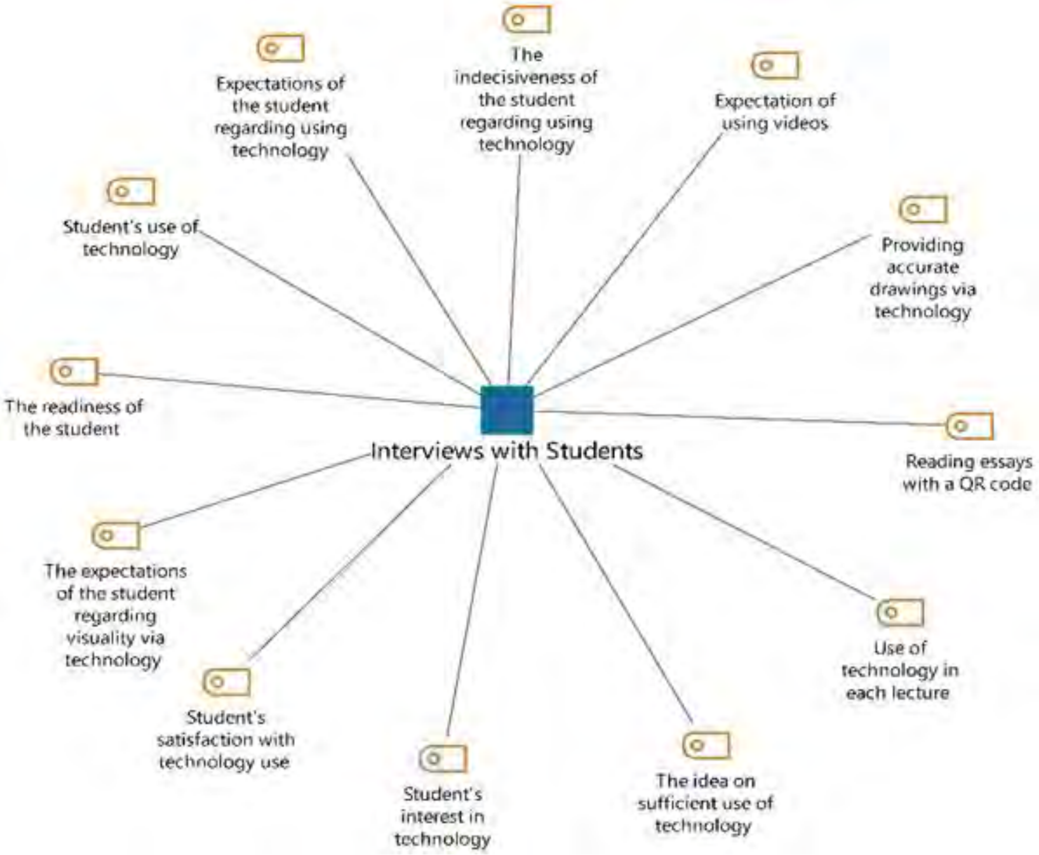

Figure 2. Code Map of the Student Interviews

> *"From a student's perspective, I see it as a way of disruption of the lecture. Most of the time it is like that. Most of the students cannot join anyways. Kahoot is useful as long as it enables many people to participate, but generally, it doesn't achieve that." (OS2 interview)*

The findings of the interviews revealed that students had high expectations about the use of technology. These expectations included the use of technology for assessment and evaluation, the use of 3D software, the use of presentations for solving questions, solving questions quickly, receiving tablets, drawing geometrical shapes, the use of software such as Geogebra, and the use of videos. Furthermore, the students stated that they could make accurate drawings using technology.

> *"There are applications in Play Store that solve mathematics questions, you need to send the square code and the application solves the question. I think that kind of application might be useful." (OS2 interview)*

> *"I would use them in a three-dimensional form as well. Indeed, such kind of use is easier in terms of time. In the end, it is a 40-minutes lecture. It should be taught in these 40 minutes. Lectures also include visuals, I think our visual memory is stronger, therefore using visuals is better." (FS1 interview)*

Another important finding of the study revealed that all of the students thought that teachers were indecisive about the duration of using technology. Although students were satisfied with their teachers' use of technology, they also expected them to use technology differently. The students also pointed out that they were in touch with their teachers all the time, and their teacher used technology for solving questions and for assessment and evaluation.

> *"The teacher opens the app and solves the question, so we have more time for ourselves." (FS1 interview)*

> *"The teacher uses it to solve questions. Indeed, we learn the subjects through questions." (OS1 interview)*

The findings also revealed that the students perceived the use of technology as solving questions. They also indicated that teachers used smartboards in the lectures, and they interacted with technology constantly.

> *"The teacher uses smartboards in every lecture, always. It is always open, in every lecture." (OS1 interview)*

> *"Smartboards are used all the time, we solve the questions on smartboards already." (FS1 interview)*

The codes obtained from the interviews conducted with the students were presented in **Figure 2**.

Findings of the administrator interviews

The interviews conducted with the administrators revealed that the teachers had difficulties related to the infrastructure. These problems included the internet connection problems regarding interactive whiteboards, and teachers were not able to use technology when they face problems regarding the internet connection.

> *"They can't turn on interactive whiteboards, there are problems somehow, maybe a plug is too loose, or they can't connect to the internet, this or that…So they can't turn on the board because connect to the internet, and therefore they can't begin the lecture. The question of whether the infrastructure is sufficient… I don't think that the infrastructure is sufficient right now." (FA interview)*

OA mentioned that he was not satisfied with the teachers' use of technology, and some of the teachers did not even possess the basic technological knowledge. The administrator also added that teachers should be open to innovation.

> *"First of all, I expect teachers to make most of the things at least at a minimum level. Most of my colleagues, teachers, are not competent in technology. Many teachers still do not use the most basic technology or follow social media. Some of them can't even send their locations on WhatsApp… You should be open to innovation, be up to date. You should catch up with the new technologies. For that, they should use the available fast communication tools." (OA interview)*

FA noted that the teachers considered technology as an instrument to make presentations, or they used it as a projector. Furthermore, the administrator added that he was satisfied with the teachers' smartboard use, and he did not know what to do more.

> *"What can be done besides presentations; indeed, there is not so much to do. Teachers use the smartboard, they open a new page and use the pencil. They generally do that. What else can be done?" (FA interview)*

FA gave an example of his expectation of technology to answer the question of how technology can be used.

> *"All teachers and students could have a device to answer multiple-choice questions. The teacher asks a question and students write down the answer. Then they can see the results on the screen of the smartboard. In this way, they could see if students understand the subject or not." (FA interview)*

In addition, OA highlighted that students were more competent in using technology compared to teachers, and teachers did not want to make mistakes while using technology to main their authority.

> *"Because they (students) are more familiar with technology, teachers do not want to deal with it at all. They use the old methods. They that to maintain their authority, but students are aware of everything." (OA interview)*

Both of the schools did not have an information technologies teacher in the permanent staff, neither a formative teacher. OA noted that the school had a formative teacher who was working part-time.

> *"In our school, we have a literature teacher who has a good understanding of technology. The teacher is also a formative teacher, but he did not accept to be a formative teacher. He has a certificate to be a formative teacher, we asked him to be the formative teacher of our school, but he didn't accept it. But when we have a problem we ask him to handle it, we do it together." (FA interview)*

Both administrators stressed that they asked teachers to take courses, wanted teachers to improve themselves and put effort to support teachers in using technology. The administrators also expressed their demands in the staff meetings and one-to-one meetings with teachers. Yet, they underlined that teachers should be also willing to improve themselves.

> *"In the meetings, we mention that technology should be used, in one-to-one meetings we talk about the ways of using technology. I can do all to encourage them to use technology. If they want to go to a course, I send them, of course." (FA interview)*

The codes obtained from the interviews conducted with the administrators were presented in **Figure 3**.

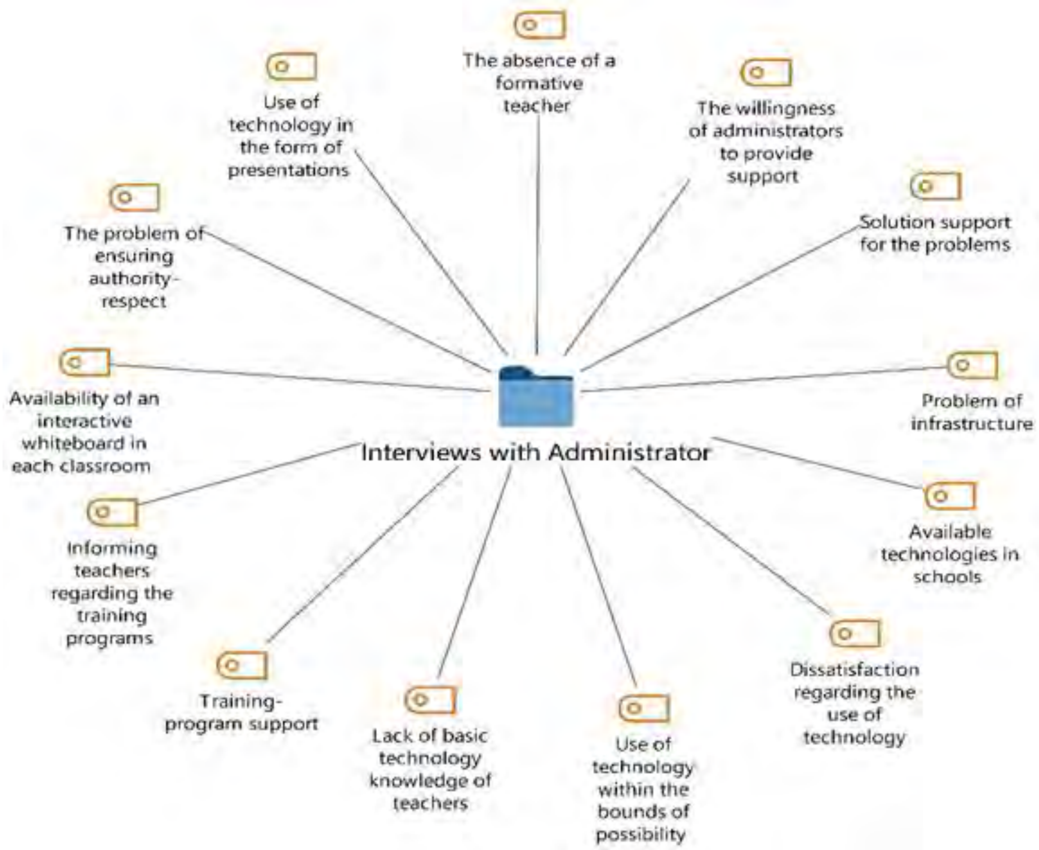

Figure 3. Code Map of the Administrator Interviews

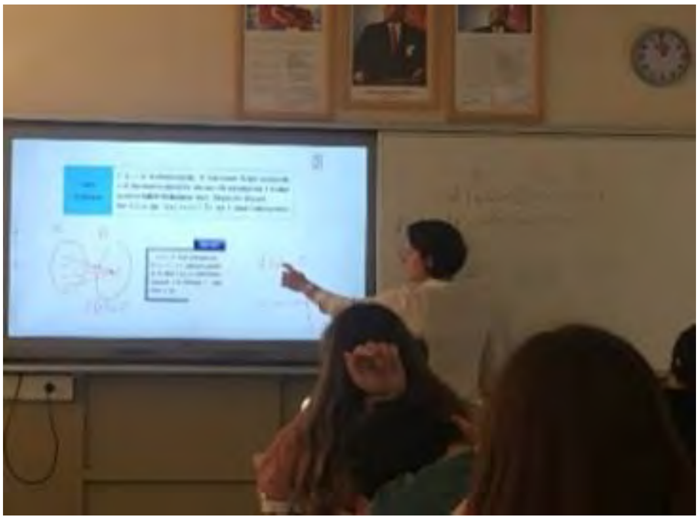

Figure 4. Example of Teacher Ozge's way of using technology

Findings of the in-class interviews

The observations revealed that Teacher Ozge used the material she prepared for the PowerPoint presentation and whiteboard for delivering lectures. The teacher used the program Kahoot! together with the students for half of the lecture, and used Geogebra only for 5 minutes in one lecture. Also, the teacher made quizzes and controlled these quizzes with the optic reader provided by the school. In one of the lectures, the teacher used a remote controller to apply the transition to slides. The observations also showed that Teacher Ozge had her graphic tablet and a YouTube account where she posted online math classes which she uploaded on EIN. She encourages her students to watch the videos on EIN. **Figure 4** illustrates Teacher Ozge's way of using technology.

The observations revealed that Teacher Firat delivered the lectures using the material that he prepared using the software program Starboard, and the whiteboard. In addition, Teacher Firat used z-books, PDFs, the FATIH pen feature of the interactive board, and Geogebra within 6 lecture hours. The teacher filled the class book via a smartphone application, sent tests to his students via EIN, and encouraged the students to use EIN. **Figure 5** illustrates Teacher Firat's way of using technology.

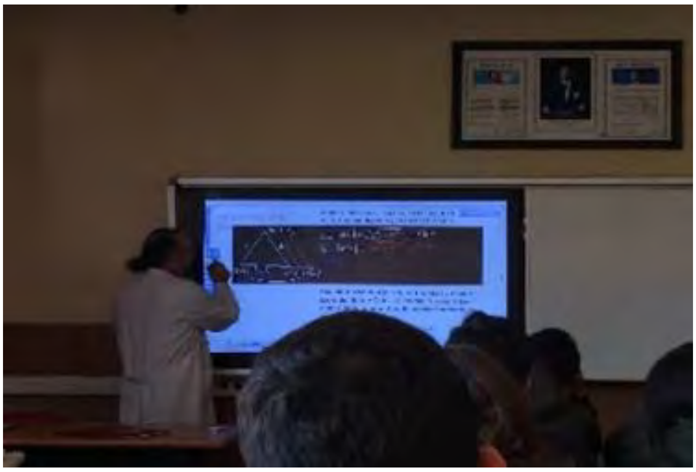

Figure 5. Example of Teacher Firat's way of using technology

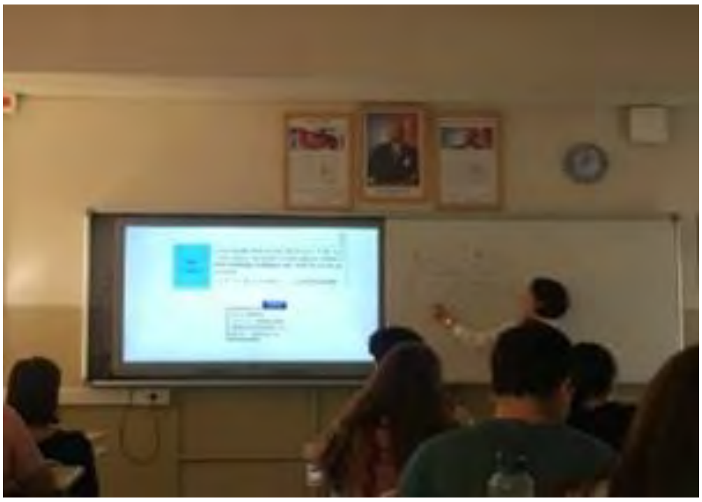

Figure 6. Providing Definitions

It is important to note that Teacher Ozge did not hesitate to express that she did not have an answer to questions when she receives a question from students. For example, when the toolbar disappeared on the screen, the teacher could not find it and asked her students "I have a question for you, you know it better than I do, the toolbar appears sometimes on the left part of the screen, and sometimes on the right side. Why does it happen? Can I fix it on this side?" (Lecture 8). The given situation can be explained by the fact that the teacher was aware of her capabilities. On the other hand, the field interviews revealed that Teacher Firat thought that a teacher should not reveal in the classroom that he does not have sufficient knowledge on a topic.

The findings demonstrated that both of the teachers developed their own materials. Although teachers' materials were original, it was seen that the questions and subjects were copy-pasted from the textbook. The pages of the material prepared by Teacher Firat were condensed (i.e. the page 150), the necessary adjustments were made by the teacher by decreasing the font size, and teacher flipped through the pages to find the page he needed. Furthermore, it was observed that there were deficient questions in the material, the teacher changed the questions during the lecture, and there were two questions on one page. These findings revealed that there was a problem regarding the design and use of the material. Furthermore, it was determined that both teachers used the information that they received from different sources in their presentations.

Teacher Ozge also prepared original materials, yet, it was seen that a presentation was duplicated in the materials, the same question was included in different forms, and there was a confusion about the number of the pages. Also, in the material, there was a presentation page related to a different subject, and there were two questions in one presentation page. In addition to the above-mentioned situations, the teacher started the lecture with difficult questions, and it was thought that it distracted the students. After providing the definition of a unit function (**Figure 6**), the teacher opened two questions to enable students to comprehend the subject better (**Figure 7** and **Figure 8**).

After the questions were solved, one of the students told to the teacher that "*If we would solve this question before (showing* **Figure 8**), *we could understand better",* and the teacher agreed with the student. This situation revealed that there were difficulties regarding the preparation of the materials. On the contrary, Teacher Ozge included mind games in the material which students enjoyed, and such questions provided an opportunity for students to focus their attention.

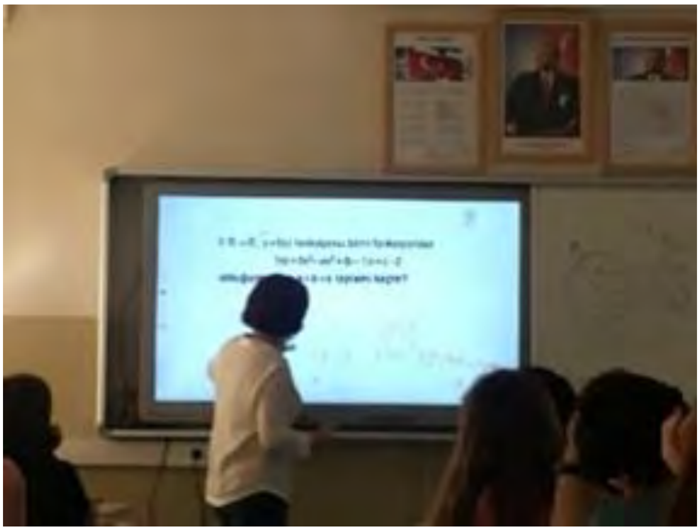

Figure 7. Question-Solving

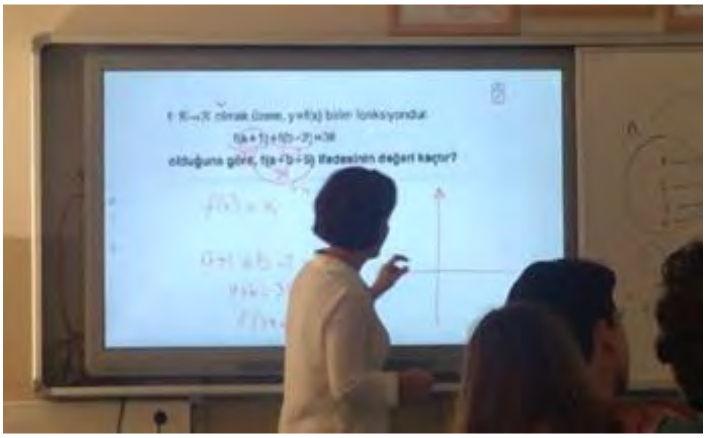

Figure 8. Question-Solving

Teacher Ozge read the explanations related to the use of concepts that were introduced recently in the introduction stage from a PowerPoint presentation. Also, she used an activity designed to attract the attention of the students through the presentation. The teacher also added the pre-test provided in the introduction chapter of the textbook to the presentation and solved the questions with the students.

Teacher Firat spent 10 minutes to solve a question, and he misguided students while interpreting the branches of the parabolas.

> *Teacher Firat: "Did it get any closer, so it can be like that, so it is like that (laughs), it gets closer to y, and moves away from x" (Lecture 18)*

The findings showed that both of the teachers used technology for assessment and evaluation. Teacher Ozge also used an optic reader. Teacher Firat organized trial tests regularly and scanned the QR code via the application that he used for the tests to see the results and the lists and share this information with students on WhatsApp. In addition to that, the study findings showed that the teachers used technology mostly for question-solving, and also use it for visualization via Geogebra.

Both of the teachers indicated that the interactive whiteboards should be turned on, so teachers do not lose time. Teacher Firat waited for the interactive whiteboard to start for 6,7,10,15 minutes. He brought an extension cord to the classroom to start up the boards. In one lecture, he did not wait for the interactive whiteboard and solved a question from the textbook with students by using the whiteboard. Teacher Ozge had to deliver the lecture using the whiteboard since the interactive whiteboard did not start up. As a solution, she solved the questions from a smartphone app (**Figure 9**). The findings showed that both of the teachers were familiar with the technology that they were using. However, although the research had spent more than a month with both teachers, it was observed that they did not use different technologies in their lectures.

The students asked Teacher Ozge to increase the font size in her PowerPoint presentation since it was too small, yet the teacher could not do it, and students had to help her. In the following lecture, she confronted the same problem, yet she could not find a solution. The teacher said "Let's make it bigger… Let's try, they have just shown if we can manage to do it…". In the given situation, the failure of the teacher to solve an issue that she faced before raised question marks regarding the familiarity of teachers with technology.

Figure 9. Shutting Down the Interactive Whiteboard

Teacher Ozge received help from the students when she faced connection problems with the internet connection of the interactive whiteboard. Also, the teacher wanted to open a link attached to the Geogebra presentation, yet the link did not work, and she used Geogebra on the web. Teacher Firat also received help from the students to enter a function input while using Geogebra.

Teacher Firat: "Could we start it, it has started, let's write a function. f x squared,

Students: "It has not started"

Teacher Firat: "It hasn't started, or? First, we write down x, then square, x…"

Students: "No, the x is squared"

Teacher Firat: "x squared plus 3, enter"

Students: "No it is not correct… it's the exponential*."*

Teacher Firat: "we can delete all of it, x…"

Students: "Incorrect, correct"

Teacher Firat: "x squared plus 3 enter… now, this is the graphic, this is the graphic, is this correct?" (Lecture 19)

The findings showed that both of the teachers could maintain the order of the classroom. Teacher Firat was walking in the classroom, warned the students who were speaking and told them their behaviour might cause receiving lower grades, and gave higher grades to students who behaved better. Teacher Ozge rarely walked in the classroom and verbally warned the students who were talking during the lecture. Furthermore, the lecture where Teacher Ozge did not use technology to solve questions was compared to the following lecture where she used technology to solve questions by using technology in the classroom. The results of the comparison showed that the students were talking in both lectures, and they talked in the second lecture more than the first lecture. In addition, the field interviews revealed that Teacher Ozge obstructed students to talk by solving questions one after another using technology.

Both of the teachers perceived mathematics education as teaching concepts and subjects to students by solving questions and preparing students for exams. The findings showed that teachers used technology for solving questions via reflecting, and the teachers' way of teaching mathematics was exam-oriented and based on solving questions. It was also seen that both teachers asked students to write or read definitions. Although the material prepared by teachers fulfilled the expectations of the students to solve questions quickly, they were not sufficient to meet the criteria of mathematics education.

9The findings showed that particularly Teacher Ozge put an effort to enable students to learn by interpreting, and to encourage students to be mentally and physically active during the lecture. In this regard, the findings showed that students often solved the questions on the whiteboard, she asked about their opinions and allowed students to share their ideas in the classroom. The teacher-guided students to reach the correct answer through her questions. On the other hand, the lecture observations revealed that Teacher Firat did not ask any questions to the students, yet students were allowed to asked questions. However, it was observed that when the teacher asked questions to students, he replied most of them on his own.

"This is an increasing function, direct proportion versus input. In this case, y increases as x increases. Let's assume that m is negative, is that correct, I assumed that m is positive here if we assume that it is negative, can we put -n/m, is that correct, if m is negative, we can put it here, so how my graph would look like, like this. If we assume this, how it would look like, as you can see, it would decrease. It means that there is an inverse proportion. So what do we have here, an inverse proportion? What kind of function is this? A decreasing function…" (Lecture 7)

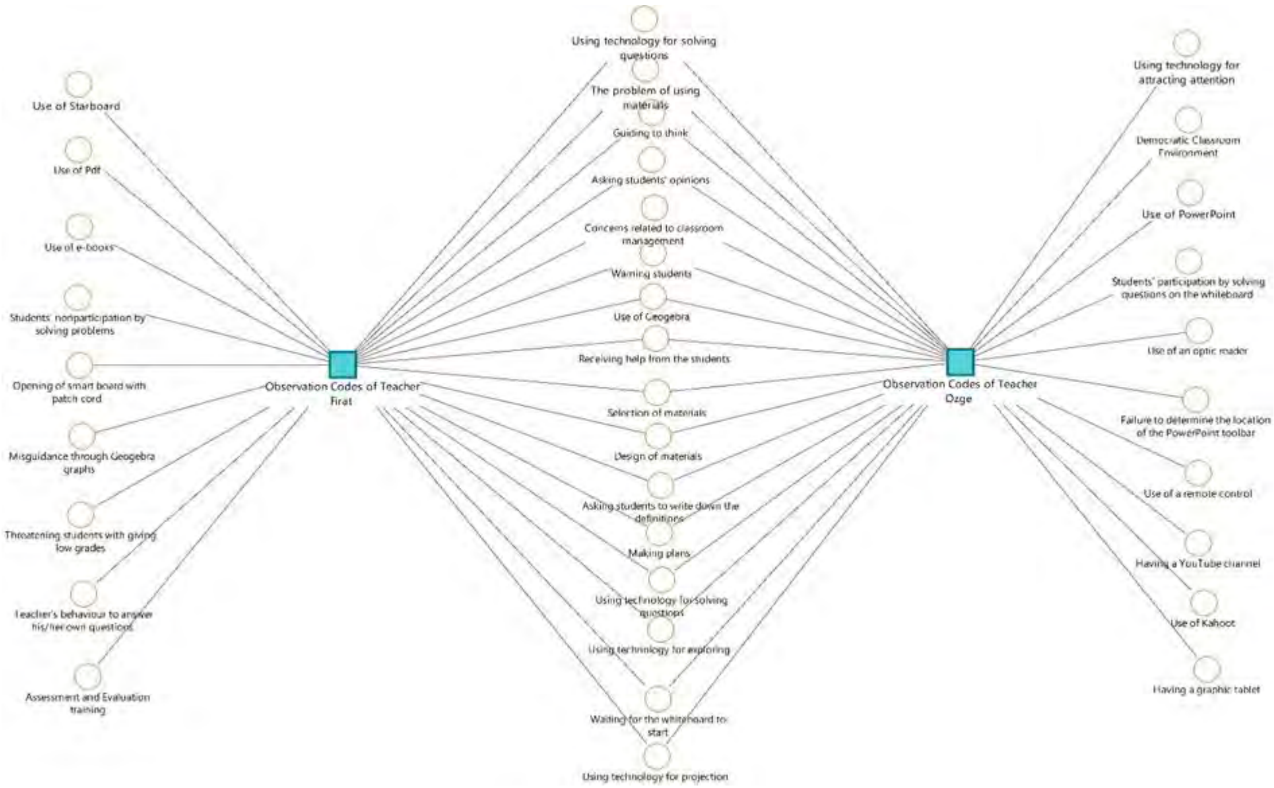

Figure 10. Teacher Observation Code Map

The codes obtained as a result of the observations are presented in **Figure 10**.

Theoretical Coding

As a result of the preliminary coding, 88 codes were created. Some of the codes were combined through focused coding, renamed, addressed under a different code or accepted as a separate code, and included in **Table 5** as a sub-code.

The categories that were obtained in the theoretical coding phase using focused coding, association, and categorization; subcategories, categories, and sub-codes were presented. **Table 5** presents the relationship between code-sub-code and category-sub-category.

Table 5. Code-Category Relationship Obtained Through Theoretical Coding

Sub-Codes	Codes	Sub-Categories	Categories
The voluntariness of the teacher	Voluntariness	Personal Factors	Teacher-Driven factors
Teacher's high level of interest in technology	Interest in Technology		
The willingness to use familiar tools	Convenience of Known		
The curiosity of the teacher	Curiosity		
Language factor	Language Factor		
Self-confidence Respect through knowledge of technology Ensuring authority	Self- Consciousness		
Openness to innovation Self-learning	Openness to Innovation		
Time allocated for technology Using technology in every aspect of life Using technology as an important aspect of work	Perception of Technology Use		
Acceptance of incompetence Willingness to be competent in technology	Self-Awareness		
Use of a remote control Having a YouTube channel Having a graphic tablet Lack of basic technological knowledge Starting the interactive whiteboard Receiving help from the students Failure to determine the location of the PowerPoint toolbar Lack of basic technology knowledge of teachers	Technological Knowledge		
Time allocated by a teacher for using technology Frequency of using technology	Technological Predisposition		

Table 5 (continued). Code-Category Relationship Obtained Through Theoretical Coding

Sub-Codes	Codes	Sub-Categories	Categories
Feasibility of active learning in the mathematics course Focusing on self-learning Teacher's use of technology in each lecture Students' participation by solving questions Teacher's behaviour to answer his/her own questions Guiding to think Asking students' opinions Waiting for students to ask questions	Perspective of Learning	Professional Factors	Teacher-Driven factors
Use of technology in the form of presentations Solving questions using technology Student's use of technology Asking students to write down the definitions	Perspective of Mathematics Teaching		
Graduate of Faculty of Education Graduate of Faculty of Natural Sciences Geogebra training program Assessment and Evaluation training program Starboard, Antropi training program	Educational Background		
Threatening students with giving low grades Concerns related to the classroom management Warning students Democratic Classroom Environment	Opinion on Classroom Management		
Use of e-books Use of Starboard Use of Pdf Use of Geogebra Use of PowerPoint Use of an optic reader Use of Kahoot Having a graphic tablet Having a YouTube channel Misguidance through Geogebra graphs	Subject Specific Technological Knowledge		
Advantage of technology for saving time in mathematics education Advantage of technology for improving the teacher Advantage of technology for attracting students attention Providing accurate drawings Negative impacts of technology	Technology Awareness		
Making plans	Planning		
Using technology for projection Using technology for making assessment and evaluation with an optic reader and QR code Using technology for visualization Using technology for solving a large number of questions Using technology for attracting attention Using technology for exploring	Purpose of Using Technology		
The problem of producing content Selection of materials Design of materials The problem of using materials	Technological Materials		
The expectation-indecisiveness of the student regarding using technology Expectations of the student regarding visuality via technology Student's satisfaction with technology use Idea on sufficient use of technology Expectation of using videos	Expectation of the Student	Student-Driven Factors	Non-Teacher-Driven Factors
The curiosity of student Technology possession of the student The readiness of the Student The interest of the student in technology	Readiness of the Student		
Informing teachers regarding the trainings Training-program support Solution support for the problems Willingness of administrators to provide support	Support of the Administrator	Administrator-Driven Factors	
The use of technology within the bounds of possibility Dissatisfaction regarding the use of technology	Expectation of the Administrator		
The absence of a formative teacher	Availability of an Individual Responsible of Technology	School-Driven Factors	
Economic status	Economic Status		
Well-equipped learning environment Availability of an interactive whiteboard in each classroom Available technologies in schools Problem of infrastructure Starting the interactive whiteboard with a connecting cable Waiting for the interactive whiteboard to start	Physical Conditions		

Table 5 shows that the factor that affected technology integration in mathematics education at most was the teachers. The findings revealed that the responsibility of integrating technology fell on teachers. In addition, the mathematics curriculum that was not mentioned by the teachers also affected teachers' technology integration on the subject basis, and therefore, mathematics curriculum approach should be also added to the framework since it might guide teachers' technology integration.

Table 6. The Definition of the Codes in the Context of the Study

Codes	Definitions
The voluntariness of the teacher	Teachers' willingness to use technology without any pressure
The interest of the teacher in the technology	Any connection or relationship between the teacher and technology
Known convenience of the teacher	Teachers' ability to use technologies that he or she is familiar with, willingness to use technologies that are known
The curiosity of the teacher	The aspiration of the teacher to understand and learn about technology
Language factor	The difficulty that the teacher has regarding using materials prepared in a foreign language
The self-confidence of the teacher	Teachers' personal feelings towards using technology regardless of fear, avoidance and doubt
The openness of the teacher to innovation	The welcoming approach of the teacher towards a new technology
Teacher's perception of technology use	The meaning of technology for a teacher, a teacher's capability to understand the technology
Self-awareness of the teacher	Self-awareness of a teacher regarding his or her capabilities
The technological knowledge of the teacher	The status of a teacher to have the basic technological knowledge
Technological predisposition of the teacher	The competence of a teacher that stems from the habits of technology use
Teacher's perspective on learning	The knowledge that explains how a teacher should form mathematical knowledge for a student
Teacher's perspective on mathematics teaching	The perspective of the teacher on his or her profession, and on his or her perception of mathematics education
Educational background	Undergraduate and post-graduate education of the teacher
Perception of the teacher regarding classroom management	The way that the teacher adopts to manage the classroom during mathematics instruction
Subject-specific technological knowledge	Technologies used by the teacher that are relevant to the subject of mathematics
Technology awareness of the teacher	The awareness of the teacher regarding the advantages and disadvantages of technology, a teacher's familiarity with technology
Planning	The organization of technology-based mathematics instruction process by a teacher
Purpose of using technology	The opinions of the teacher regarding the purpose of using technology
Technological material	The selection, production and design of the technological materials used by the teacher, and problems related to the use of the materials
The expectation of the students	The expectations of students from the technological devices in the learning process
The readiness of the student	The technological, infrastructural, and personal possession of students for technology-based mathematics education
Support of the administrator	The status of administrators to support the teacher for technology-based instruction, and their level of satisfaction
Expectations of the administrators	Anticipations and expectations of administrators regarding the provision of technology-based instruction by the teacher
Availability of an individual responsible of technology	The availability of an individual responsible for technology (related issues)
Economic status	Having financial opportunities
Physical conditions	The available infrastructural, technical and software related conditions
Mathematics curriculum	Program that was used by mathematics teachers a guide, which included knowledge, skills, and learning outcomes that students should obtain
Mathematics curriculum approach	Student-centered, based on the constructive approach, and focused on improving students' skills.

The mathematics curriculum is a program that was used by mathematics teachers as a guideline, which included knowledge, skills, and learning outcomes that students should obtain. On the other hand, mathematics curriculum approach was student-centered, it is based on the constructive approach, and focused on improving students' skills. **Table 6** shows the definition of the codes in the context of the study.

Figure 11 presents the framework created in the classification and schematization phase of the study bases on the codes and categories obtained in **Table 5**.

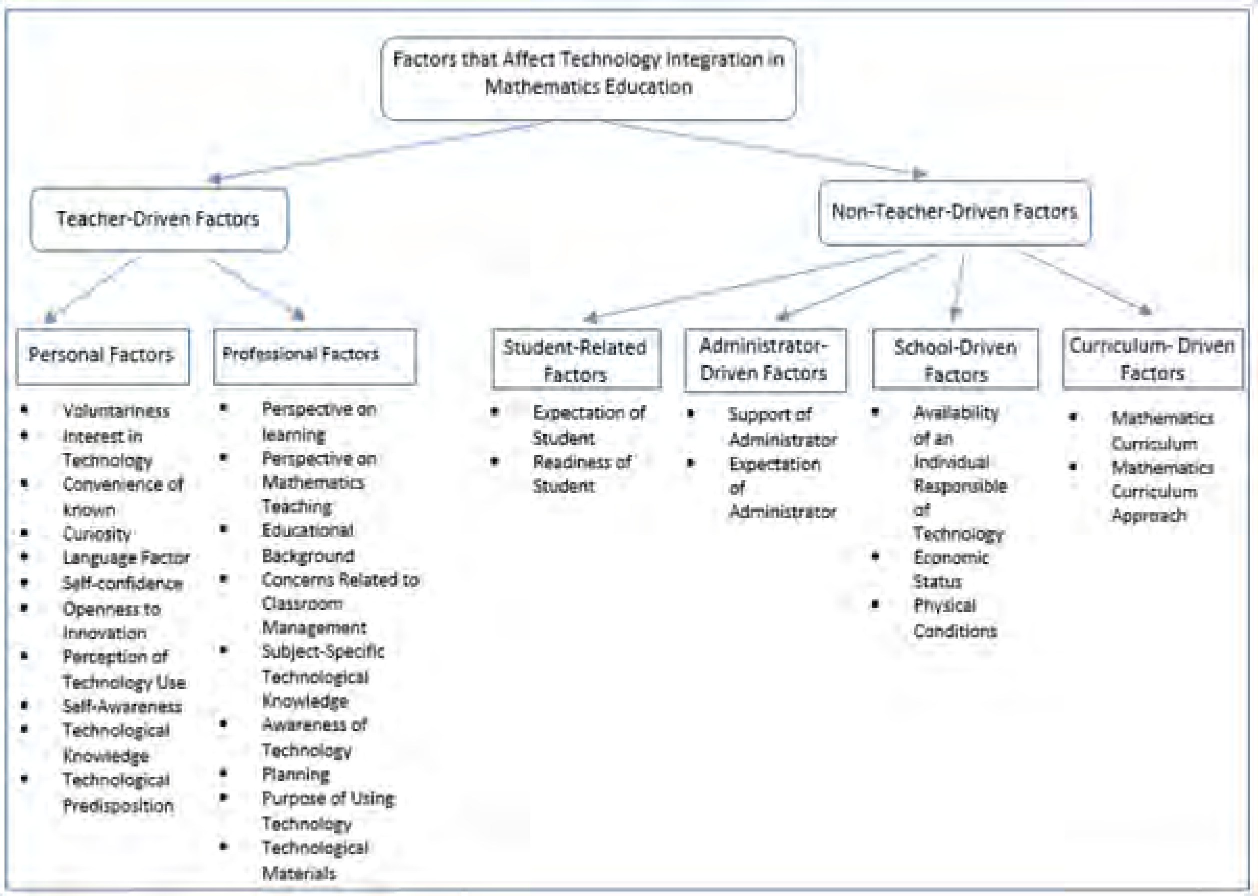

Figure 11. The Framework of Factors that Affect Technology Integration in Mathematics Education

RESULTS, DISCUSSION AND SUGGESTIONS

The framework that was formed by using the research findings was based on the assumption that the teacher was responsible for the management of the process, but also considered that non-teacher-related factors also had an impact on the process. Therefore, two main groups of factors were established including teacher-related factors and non-teacher-related-factors. The teacher-related factors were also grouped as personal and professional factors. The personal factors were specified as voluntariness, interest in technology, the convenience of known, curiosity, language factor, self-confidence, openness to innovation, perception of technology use, self-awareness, technological knowledge and technological predisposition. On the other hand, the professional factors included perspective on mathematics teaching, educational background, concerns related to the classroom management, subject-specific technological knowledge, awareness of technology, planning, the purpose of using technology, technological materials. Furthermore, the non-teacher-related factors were specified as expectation of the student, readiness of the student, support provided by the administrator, expectation of the administrator, availability of an individual responsible of technology, economic status, physical conditions, mathematics curriculum and mathematics curriculum approach.

In the literature, the "factors that affect technology'' were classified in two groups: external-primary and internal-secondary factors (Ertmer, 1999; Snoeyink & Ertmer, 2001). The internal factors included the factors that affect individuals such as culture, attitude, beliefs; and the external factors included equipment, education, and resources. In this study, a framework that addresses the individual, yet, based on a teacher rather than an individual and considers other factors as factors that are not related to the teacher. Many studies stressed that the teacher is the most important factor in the integration process (Knezek, Christensen, Hancock & Shoho, 2000; Koehler & Mishra 2009; Mishra & Koehler, 2006; Ertmer, 1999; Bhasin, 2012). In line with the literature, the results of this study also showed that a teacher is an individual who achieves technology integration. Furthermore, the teacher-related factors presented in the literature were analysed under personal factors and professional factors.

Although personal factors were assumed to be equivalent to the internal-secondary factors included in the literature in the first stage, new concepts have emerged as a result of this study. One of the personal factors included in the study, "technological knowledge" was also highlighted by Mishra and Koehler (2006), Goos (2005) and Pierce and Stacey (2013). The concept of "Voluntariness" was highlighted by Venkatesh and Bala (2008), and the concept of "self-confidence" was stressed by Van Baraak (2001). Furthermore, the concepts of "interest", and 'curiosity" were marked by Knezek et al. (2000), and Arnone, Small, Chauncey and McKenna (2011). The concept of "openness to innovation" was reported as a low factor by Van Baraak (2001), yet it was considered as an important factor in this study, and also in the studies of Kaya and Kocak-Usluel (2011). In addition, the study showed that the willingness of teachers to use the tools which they were familiar was explained by the concept of "convenience of known", which was considered as an important concept that affected technology use. Another concept, "self-awareness", which was the self-knowledge of a teacher regarding his or her own capabilities, was also found important in the use of technology. On the other hand, the concept of "self-efficacy" which was included in the literature did not emerge in this study. Also, teachers' "perception of technology", in other words, what technology meant for teachers, was found as an important concept. The concept "language factor" was determined as an important factor that affected the technology use of mathematics teachers in Turkey. In the study, the concept of technology use was defined as a competence that emerged from the habits of a teacher. This concept was preferred since other concepts such as skills or talent did not include the intended meaning precisely. In this line, the studies of Knezek et al. (2000) and Kaya & Kocak-Usluel (2011) revealed that self-perception of teachers, which refers to their judgments about themselves such as being skilled and talented also indicated that they were more willing to try to use technology.

The framework created in the study presented the "educational background" as the primary professional factor that affected teachers' use of technology. The educational background and professional improvement of the teachers were highlighted as factors that had an impact on technology integration (Bauer & Kenton 2005; Kaya & Kocak-Usluel, 2011; Kılınc et al., 2018; Ertmer et al., 2006). Furthermore, "making plans" was found as a factor that affected the integration process. Lee &Lee (2014) argued that making plans did not have an impact on the perception of the teacher in the technology integration process; yet Bauer & Kenton (2005) and Canbazoglu-Bilici, Guzey & Yamak (2016) found out that making plans affected teacher decision making processes comprehensively. The framework demonstrated that "technological materials" also affected technology integration. Preparing technological materials, having an access to available materials, using and selecting them, and their association with the course objectives affected integration (McCulloch, Hollebrands, Lee, Harrison & Mutlu, 2018). According to Tosuntas et al. (2019), in Turkey, the main source of the materials is EIN, yet, the quality and quantity of the materials are subject to another discussion. Lastly, "technological knowledge related to the subject" which was included in the framework was supported by Mishra & Koehler (2006), Koehler & Mishra (2009), and Washira & Keengwe (2011).

In the literature, teachers' "concerns related to classroom management" were presented under general concerns related to the use of technology. Teachers' concerns were described as a factor that affected technology use and integration (Zbiek & Hollebrands, 2008; Venkatesh & Bala, 2008). In this study, the concerns related to classroom management were particularly highlighted as teachers were not capable of classroom management while they were integrating technology. Another reason of highlighting the concept was associated with the teachers' opinions on designing or organizing materials for managing the classroom. In this sense, "teachers' concerns related to the classroom management'' was underlined as a significant concept. Teacher's "purpose of using technology" was defined as their opinion on the purpose and method of using materials while designing the instruction process. Although this concept was not included in the literature directly, some studies revealed that teachers use technology for making evaluations, solving questions, (Tuysuz & Çumen, 2016), and preparing for exams (Tosuntas, 2017), which were consisted with the results of this study. Furthermore, the concept of "technology awareness" was included in the literature with the framework developed by this study. The awareness of a teacher about the positive and negative aspects of technology was among the factors that played a role in technology integration. Thus, the teacher was expected to design and plan the lecture based on these opinions.

In the framework, another important factor that affected a teacher's technology integration in mathematics education was defined as "perception of learning". This concept was defined as how a teacher should create mathematical knowledge for students. The important point at this juncture was the learning approach adopted by the teacher and his or her way of applying it in the lecture. The active and passive participation of students in class, and the constructivist approach adopted by the teacher affected the integration process. In the literature, the dominant view argued that constructivist and the student-centred teaching approaches had an impact on the effective integration of technology (Ertmer, 2005; Weis, 2009). The study conducted by Prasojo, Habibi, Yaakob, Mukminin, Haswindy & Sofwan (2019) pointed out to traditional teaching techniques as factors that affected technology integration negatively.

Another important factor was emphasized as the teacher's "perspective on mathematics teaching". It is believed that in Turkey, mathematics teachers are familiar with the constructivist approach, yet do not commonly adopt it. Therefore, asking students to memorize concepts and formulas, and delivering the lectures over questions instead of creating concepts and enabling students to explore them have become the preference of many teachers. In the literature, few studies focused on this matter (Tosuntas, 2017), and it is concerning that mathematics teachers do not prefer to include this concept in technology integration.

Besides the factors that affected the teacher, non-teacher-related factors were also among the two main factors stressed by the study. The non-teacher-related factors were analysed in four groups including student-driven, administrator-related, school-driven, and curriculum-driven factors.

The analysis led to the conclusion that "expectation of the student" which was a student-related factor, might affect the teacher's technology integration, and the teacher might change and improve his or her use of technology according to the demands of the student. A teacher was expected to consider "student" readiness while integrating technology. In this context, student readiness referred to the organization of the process by the teacher by taking students' opportunities to use technology into consideration. In line with these views, the student factor was emphasized by Grouf and Mouza (2008), and Gunuc (2017).

The analysis showed that the "administrator expectation", which was included in administrator related factors, might affect technology use. As long as the administrators did not have any expectations from the teachers, teachers might not take action to use technology in teaching processes or might use technology only for administrator satisfaction. Furthermore, "administrator support" was also stressed as another important factor. Many studies highlighted the role of administrators and support provided by administrators in the technology integration process (BECTA, 2004; Ertmer, 1999; Groff & Mouza, 2008; Gunuc, 2017; Kaya & Kocak-Usluel, 2011).

The school-related factors, such as “availability of an individual responsible for technology” also affected the teachers’ technology use significantly. The availability of an individual who is responsible for technology-related issues and providing technical support to solve a problem immediately was considered as a factor that would affect the teacher’s convenient use of technology. The lack of technical support was also mentioned in the studies of Snoeyink and Ertmer (2001), Ertmer (2005), Harris and Sullivan (2000), Yildirim (2007), and Erduran and Ince (2018). The framework also emphasized the role of “economic status” in technology use. In line with this argument, Dvorak and Buchanan (2002) and Prasojo et al. (2019) also addressed economic status as a factor that affects technology integration. Another factor that was included in the framework was “physical conditions”, and it was assumed that the factor would affect the teacher’s technology use. Many studies argued that effective integration was not feasible in the absence of sufficient physical conditions (Groff & Mouza, 2008; Hew & Brush, 2007; Kaya & Kocak-Usluel, 2011; Korkmaz & Avci, 2016).

In addition to the above-mentioned concepts, the study pointed out the curriculum-related factors that were included in the framework by the researchers such as the “Mathematics Curriculum” and “Mathematics Curriculum Approach”. The “mathematics curriculum” provided insights about in which steps teachers should use technology, and relevant guidelines to use technology. However, it was found out that teachers did not examine the program in detail, and this situation affected technology integration process negatively. It was believed that the “Mathematics-Curriculum” affected the teacher’s technology integration on a subject basis. It was argued that the “Mathematics Curriculum Approach” might guide teachers’ integration. The curriculum approach is based on the constructivist understanding and is focused on the competencies and skills included in the curriculum. The main purpose of the education system is to educate students who have knowledge, skills, and behaviours along with our values and competencies (MoNE, 2018b). Considering this purpose, it was observed that the teachers did not engage in such studies and focused on mathematical competencies and core competencies regarding science and technology.

This study identified the factors that affected mathematics teachers’ technology integration, conceptualized these factors, and suggested a framework. The results of the study aimed to contribute to the process of planning and design of technology integration in mathematics education. The limitations of this study included the conditions that teachers who participated in the study were had been using technology, the students faced difficulties to express themselves, and only two administrators participated in the study. The framework provided in the study is expected to be used by the mathematics teachers to shape their integration processes, and mathematics educators are expected to enhance their studies in this context. Furthermore, in the process of the study, preparing technological materials and accessing such materials were found to be effective on teachers, therefore, future studies on this aspect are recommended. In conclusion, further studies which will test the factors that emerge as a result of this framework, and the association between these factors using different research designs are necessary.

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