A CASE STUDY OF ONLINE COMMUNITY OF PRACTICE FOR TEACHER PROFESSIONAL DEVELOPMENT ON TECHNOLOGY INTEGRATION AS COGNITIVE TOOLS IN MATHEMATICS TEACHING

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ABSTRACT

A CASE STUDY OF ONLINE COMMUNITY OF PRACTICE FOR TEACHER PROFESSIONAL DEVELOPMENT ON TECHNOLOGY INTEGRATION AS COGNITIVE TOOLS IN MATHEMATICS TEACHING

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While teachers' participation in a teacher network is highlighted in effective professional development and online learning removes some limitations, online communities of practice (online CoP) have emerged as a promising way for teacher professional development. Considering the discrepancy between research suggesting integrating technology to improve students' understanding and metacognitive skills and teachers' practices with teacher-centered approaches and a learning-from-medium perspective, online CoPs can provide the necessary support for teachers. Within a continuous and collaborative learning environment, teachers can gain the competencies required to incorporate technology as a learning partner and benefit from cognitive tools for students' understanding mathematics. The purpose of this exploratory single case study was to explain the impact of an online CoP designed for mathematics teachers' professional development about the integration of technology as cognitive tools. 24 mathematics teachers participated in this study. Interviews, lesson plans, and online discussion recordings were used to collect qualitative data. The findings demonstrated teachers' experiences in integrating cognitive tools as well as the indicators of constructivist learning environments in their lesson plans. Furthermore, the study revealed teachers' experiences in an online

CoP while learning how to integrate a cognitive tool into their practices, as well as their knowledge construction throughout the online discussions. Based on the findings, the study proposed a set of suggestions for designing teacher professional development programs and designing and implementing lesson plans integrating cognitive tools.

Keywords: Constructivist Learning Environments, Cognitive Tools, Online Community of Practice, Teacher Professional Development

ÖZ

MATEMATİK EĞİTİMİNDE TEKNOLOJİNİN BİLİŞSEL ARAÇ OLARAK KULLANIMINI HEDEFLEYEN ÖĞRETMEN MESLEKİ GELİŞİM PROGRAMI İÇİN BİR ÇEVRİM İÇİ UYGULAMA TOPLULUĞU: BİR ÖRNEK OLAY ÇALIŞMASI

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Etkili mesleki gelişimde öğretmenlerin bir öğretmen ağına katılımı vurgulanırken ve çevrim içi öğrenme bazı sınırlamaları ortadan kaldırırken, çevrim içi uygulama toplulukları (çevrim içi UT) öğretmenlerin mesleki gelişimi için umut verici bir yol olarak ortaya çıkmıştır. Teknolojinin öğrencilerin anlamasını sağlamak ve üst-düzey düşünme becerilerini geliştirmek için kullanılmasını öneren çalışmalar ve öğretmenlerin öğretmen merkezli ve teknolojiyi teknolojiden öğrenilen bir araç bakış açısıyla entegre eden uygulamaları arasındaki farklılık düşünüldüğünde, çevrim içi UT öğretmenler için gerekli desteği sağlayabilir. Öğretmenler, sürekli ve işbirlikli öğrenme ortamı içinde teknolojiyi bir öğrenme ortağı olarak dahil etmek için gereken yeterlilikleri kazanabilir ve öğrencilerin matematiği anlamaları için bilişsel araçlardan yararlanabilirler. Bu keşfedici tek örnek olay çalışmasının amacı, teknolojinin bilişsel araçlar olarak entegrasyonu hakkında matematik öğretmenlerinin mesleki gelişimi için tasarlanmış çevrim içi bir UT'nin etkisini açıklamaktır. Çalışmaya 24 matematik öğretmeni katılmıştır. Nitel verileri toplamak için görüşmeler, ders planları ve çevrim içi tartışma kayıtları kullanılmıştır. Bulgular, öğretmenlerin bilişsel araçları entegre etme deneyimlerini ve ders planlarında yapılandırmacı öğrenme ortamlarının göstergelerini ortaya koymuştur. Ayrıca, çalışma, öğretmenlerin bilişsel bir aracı uygulamalarına nasıl entegre edeceklerini öğrendikleri UT'deki deneyimlerini ve ayrıca çevrim içi tartışmalar süresince bilgi oluşturmasını göstermiştir. Araştırma bulgularına dayalı olarak, çalışma, öğretmen mesleki gelişim programlarının tasarlanması ve bilişsel araçları entegre eden ders planlarının tasarlanması ve uygulanması için bir dizi öneri sunmuştur.

Anahtar Kelimeler: Oluşturmacı Öğrenme Ortamları, Bilişsel Araçlar, Çevrim İçi Uygulama Topluluğu, Öğretmen Mesleki Gelişimi

Dedicated To

My Beloved Family

Who Supported Me Throughout This Journey

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ABBREVIATIONS

CoP: Community of practice

CLE: Constructivist learning environment

MoNE: Ministry of National Education

TPD: Teacher professional development

CHAPTER 1

INTRODUCTION

This study aims to uncover the impact of an online community of practice for teacher professional development on integration of technology as cognitive tools in mathematics classes. In this teacher professional development program, teachers were involved in asynchronous and synchronous activities to learn constructivist learning environments, examine sample lesson plans, co-construct lesson plans integrating cognitive tools, implement the lesson plans in their classrooms and discuss their opinions and experiences. In this chapter, the following sections are contained: background of the study, statement of the problem, purpose of the study and research questions, significance of the study, and definition of terms.

1.1 Background of the Study

In the age of digital economy, the technological advancements require changes in education to meet the needs of this age. There is a direct impact of technological developments on what education aims (Voogt & Knezek, 2018). In the twenty first century, the use of information and communication technologies (ICTs) is considered as a competence for lifelong learning, which is needed for personal fulfilment, active citizenship, social cohesion, and employability in a knowledge society (Grek, 2010). Moreover, many studies underlined the potential role of ICT in effective teaching and learning process (Sandholdtz, Ringstaff & Dwyer, 1997; Voogt, Tilya & Van den Akker, 2009; Williams, Linn, Ammon & Gearhart, 2004) and the positive effect of ICTs on student achievement when students work on student-centered activities collaboratively (Becker & Ravitz, 2001; Carter & Smith, 2001; Li & Ma, 2010; Shapley, Sheehan, Maloney, & Caranikas-Walker, 2011). Hence, integration of ICT in education has become a major topic in twenty first century. Appropriate use of various ICTs is stated as ways of expanding the accessibility to education, enhancing the connection between education and the digital workforce, and improving educational quality by contributing to create engaging, active and real-life based learning environments (Pedro, 2006).

Regarding ICT as “a learning tool and the mediator of a nation’s educational goals” (Baser-Gülsoy, 2011, p.1), Aydın, Gürol and Vanderlinde (2016) underlined the need of revising the curriculum and integrating technology into the teaching and learning process to get the intended educational results. There are many examples that have started large-scale technology integration programs in different countries like the UK, Turkey, Uruguay, Peru, Korea, China, Mexico, India and Malaysia (Aydın, Gürol & Vanderlinde, 2016). In Turkey, FATIH Project (Movement of Enhancing Opportunities and Improving Technology) which was initiated by Ministry of National Education (MoNE) aims to improve schools’ technological opportunities and enhance technology use in classrooms. Moreover, Turkey’s formal curriculum emphasized the use of educational technologies within teaching and learning process (MoNE, 2018). In this context, the recent Turkish elementary mathematics curriculum mentioned the competencies in mathematics, science, and technology (MoNE, 2018). Technological competence is considered as “the application of knowledge and methodology in the context of meeting perceived demands and needs” (MoNE, 2018, p.6). Although formal curriculum in Turkey has underlined learner-centered and constructivist approaches since 2005 and the recent curriculum has highlighted the use of education technologies to support learning with these approaches (MoNE, 2017), studies indicated that there were problems in both the implementation of constructivist approaches and the integration of ICT with a constructivist perspective as stated by Uslu (2017). ICT was integrated into teaching at a low level or a basic level (Aslan & Zhu, 2015; Tezci, 2009) and it was mainly used in teacher-centered activities (Keleş, Öksüz, & Bahçekapılı, 2013; Türel, 2012). On the other hand, the integration of ICTs is suggested to be applied through various teaching methods and approaches, especially constructivist approaches (Fu, 2013; Xavier, Tina, Matti & Inocente, 2018). Hence, it is essential to conduct teacher professional development programs that enable students’ learning with technology by means of constructivist approaches.opment program in this study focuses on positioning technology in students' learning with a constructivist approach.

When the factors influencing the use of ICT in education are reviewed, there can be seen studies related to teachers' attitudes towards technology (Çakıroğlu, 2015; Pamuk et al., 2013; Şahin et al., 2013), pedagogical beliefs of teachers (Baser-Gülsoy, 2011; Mümtaz, 2000) and ICT training (Hismanoğlu, 2012; Tondeur, van Keer, van Braak & Valcke, 2008) with the focus of teacher characteristics. Moreover, there are studies indicating other factors in technology integration such as ICT policy (Göktaş, Yıldırım & Yıldırım, 2009; Tondeur et al., 2008), ICT infrastructure and school culture (Akbaba-Altun, 2006; Tondeur et al, 2008). In a recent study based on the factors influencing the integration of technology in lower secondary schools in Turkey, Aslan and Zhu (2018) indicated that perceived competence in technology integration and pedagogical knowledge were significant predictors in teachers' integration of technology into their classrooms. They also stated that teachers should acquire and apply ICT skills integrating with their subject courses with changing their beliefs about teaching with technology (Aslan & Zhu, 2018). Regarding this suggestion for encouraging teachers' technology integration practices through increasing their perceived competence, it is crucial to provide an environment that allows teachers experience a new approach in technology integration in relation to their subject areas, which is mathematics.

Teachers have a significant role of facilitating student learning, creativity, and innovation by using their knowledge of the subject matter, teaching, learning and technology (ISTE, 2008). With technological advancements providing opportunities for education, the role of teachers has been studied in designing technology enhanced learning environments increasingly (Goodyear, 2015; Kali, McKenney & Sagy, 2015). Although there is an emphasis on technology integration in education, technology is generally considered as an add-on instrument rather than a significant element integrated into teaching activities (David & Falba, 2002; Jimoyiannis, 2010). Jonassen and Reeves (1996) mentioned a misguided approach stating that students should learn "from" technology rather than use technology as tools while learning. Learners are considered as knowledge consumers while learning “from” technology instead of knowledge constructors and synthesizers (Cuban, 2001). At this point, cognitive tools have been discussed to learn “with” technological tools. Jonassen and Reeves (1996) defines cognitive tools as “technologies that enhance the cognitive powers of human beings during thinking, problem solving, and learning” (p. 693). Using technology as a cognitive tool requires teachers to integrate technology in the classrooms to help students think and construct their own knowledge. Moreover, the recent technology plan of United States (U.S. Department of Education, 2016) also states the difference between the use of technology as a tool for creating, designing, building, exploring, and collaborating, and the use of it as a passive consumer. With a similar approach, Papert (1991) explained learning as constructing knowledge structures in a context where the learner produces an artifact. This approach was named as constructionism and the concept of learning by making (Papert, 1999) is in line with integrating technology as cognitive tools.

In order to integrate cognitive tools into the lessons effectively, teachers need to accomplish various tasks. Wang, Hsu, Reeves and Coster (2014) states the tasks of teachers while integrating cognitive tools as follows:

> “In order to meaningfully integrate cognitive tools, teachers must master the features of various technologies, manage the learning environment to enable students' access to these technologies, help students master the skills of using the tools, and help students make informed decisions on using appropriate tools to enhance their learning processes and communicate their learning outcomes.” (p. 104)

These challenging tasks make teachers feel threatened and affect shifting technology integration approach from teacher-centered approaches to student-centered approaches negatively (Wang, Hsu, Reeves & Coster, 2014). This is challenging for teachers. Moreover, teacher education programs whose role is to prepare future teachers contain courses focusing on the hardware or software that is considered suitable to use in classrooms rather than theoretical and pedagogical concerns that define the curriculum (Phillips, Kennedy & McNaught, 2012). The knowledge and skills preservice teachers gained in such courses are temporary and expiring before they implement the ideas in the classroom, so it is critical to provide a solution involving emerging technologies as tools rather than the objects of the study (Herrington & Parker, 2013). Teachers should know that technology, itself did not affect student outcomes positively, how technology was used and integrated into teaching and learning process leaded to positive learning outcomes (Buabeng-Andoh, 2012). It is suggested that teachers should consider the learning goals of their lesson while deciding to use a technology, but this takes more time (Ermeling, Heibert, & Gallimore, 2015).

Supporting teachers to help them use technology as a cognitive tool with a constructivist approach has critical value in education. Use of technological tools to help students' construction of knowledge has been emphasized by many studies (Chiou, Tseng, Hwang, & Heller, 2010; Chu, Hwang, Tsai, & Tseng, 2010; Hwang & Chang, 2011). Moreover, these computer applications are defined as mindtools regarding their role in students' interpretation and organization of their personal knowledge where students function as designers (Jonassen, Carr, & Yueh, 1998). When cognitive tools are used in a constructive framework, students are provided a variety of critical, creative, and complex thinking opportunities (Campbell, Wang, Hsu, Duffy, & Wolf, 2010; Hsu, Wang, & Runco, 2013; Wang, Hsu, & Campbell, 2009). A recent study indicated that use of a visualization-based cognitive tool support students' learning through scaffolding simple-to-complex tasks and enabling them to apply their learning in a project-based learning environment (Peng, Wang, Sampson & van Merriënboer, 2019). There are also studies indicating the promising effect of cognitive tools in students' learning and performance in different contexts (Gijler & de Jong, 2013; Wang, Cheng, Chen, Mercer, & Kirschner, 2017; Wang, Wu, Kirschner, & Spector, 2018). Technology provides the possibility for enhancing students' intellectual capabilities (Heid, 1997), but this opportunity is based on how teachers integrate technology in their teaching practices. There are studies indicating that through an ongoing professional development focusing on the use of emerging technologies aligned with constructive approaches, positive teacher and student outcomes observed (Lussier, Gomez, Hurst & Hendrick, 2007; Quintana et al. 2004). Hence, providing support and guidance through a professional development program about integration of cognitive tools would help teachers to position technology as a partner of students in developing students' cognitive skills.

1.2 Statement of the Problem

While the main goal of technology integration investments is based on the use of technology as a tool in learning process and the educational reforms underlines the role of technology in constructivist environments, teachers generally integrate technology into classroom practice as a passive learn-from medium (Wang, Hsu, Reeves, & Coster, 2014). Although technology is suggested to be integrated into classroom practice as a tool to improve students' understanding and higher-order cognitive skills (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur, 2012; Ward &Parr, 2010), few teachers integrate technology by using its full potential for students' meaningful learning (Lim & Chai, 2008; Talvid, 2016; Webb & Cox, 2004). Regarding Turkish students' poor performance in mathematics (MoNE, 2016), the integration of cognitive tools in mathematics classes can make a difference in student learning through teachers' effective technology integration with a constructivist approach. However, Turkish mathematics teachers have insufficient knowledge and experience in the integration of ICTs into their classes (Birgin et al., 2020). At this point, the need of pre-service and in-service teacher training programs based on how to convert a computer-based tool into a cognitive tool is highlighted (Akyol & Sendurur, 2019). There has been still a need to consider the ways of supporting teachers for the use of cognitive tools as a partner of students in their practices for the integration of ICT within constructivist learning environments.

In order to provide the required support for in-service teachers, there is a need for designing effective professional development programs. The current studies indicated that teachers' collaborative work on designing technology integrating activities encouraged them to engage in meaningful discussions about their practice, share their experience and knowledge and provide feedback for each other (Khalif, Gok & Kouraïchi, 2019; Cviko, McKenney & Voogt, 2014; Kali, McKenney & Sagy 2015). In addition to collaboration, continuous professional development activities were underlined (Akbulut, Odabaşı & Kuzu, 2011). Moreover, for improving teachers' technology integration skills, it is also suggested that teacher training programs in technology integration should have been designed based on the subjects (Salam, Zeng, Pathan, Latif & Shaheen, 2018). Considering the potential of well-designed communities, whether they were online or face-to-face, that create opportunities for teachers to learn, grow and change their teaching practice with collegial support (Duncan-Howell, 2010; Wesely, 2013; Owen, 2014; Chen, Lee, Lin, & Zhang, 2016), choosing online community of practice for the teachers' professional development in the integration of cognitive tools within a constructivist learning environment might be a promising way in terms of continuous, collaborative, and subject-based professional development.

1.3 Purpose of the Study and Research Questions

The relevant literature highlighted the significant role of teachers in technology integration. In mathematics education, it is stated that technology integration could make a difference when it is used effectively within a constructivist learning environment; however, teachers' use of technology is very limited and based on teacher-centered activities. Moreover, the results of international and national exams in which Turkish students performed poorly in mathematics highlighted the need of designing effective mathematics learning environments where students' thinking is enhanced. Teachers need professional development programs to learn how to design their teaching activities with cognitive tools to enhance students' thinking. In order to support teachers continuously within a collaborative environment, online community of practices can be considered as a promising way.

Based on the suggestions and findings of the previous studies, this study focuses on a teacher professional development program which involves elementary mathematics teachers in designing constructivist lesson plans by integrating cognitive tools. The purpose of this study is to explore the impact of the teacher professional development program through an online community of practice on elementary mathematics teachers' integration of technology as cognitive tools in their lessons.

Research questions that guide this study are as follows:

1. What are the opinions of teachers on technology integration in mathematics teaching prior to the implementation of online CoP?

2. How does online CoP for teacher professional development about the integration of technology as cognitive tools affect elementary mathematics teachers' technology integration as cognitive tools in mathematics teaching?

    2.1. What knowledge construction levels are observed in the online discussions during online CoP?

    2.2. What are the indicators of technology integration as cognitive tools in the lesson plans designed by teachers?

3. What are the opinions of teachers on the impact of participation in online CoP on their technology integration practices as cognitive tools?

1.4 Significance of the Study

This study has potential contributions to technology integration research, the practitioners which are elementary mathematics teachers and the instructional designers of both elementary mathematics curriculum and teacher professional development programs.

Technology integration research revealed that teachers have the key roles in integrating technology. Moreover, it indicated that for supporting students' learning process, teachers can position technology as a partner in students' learning, in other words, as a cognitive tool. While the role of teachers in the integration of cognitive tools has been considered as a significant factor, there is a need for empirical evidence on the impact of cognitive tools on teachers' practices (Wang, Hsu, Reeves & Coster, 2014). The existing research does not provide a clear understanding of how teacher professional development programs affect teachers' integration of technology as a partner of students in their learning process. In this context, this study is expected to contribute to technology integration research by examining the impact of an online teacher professional development program about the integration of cognitive tools in mathematics teaching on teachers' opinions and practices. Moreover, within the context of this online CoP, it can also help identifying experiences and challenges of mathematics teachers in preparing lessons integrating technology with a constructivist approach as suggested by Onyango and Gitonga (2017), which can also inform the instructional designers of curriculum aiming to integrate technology effectively.

For practitioners, the focus of "learning with technology" approach is also suitable with the aim of gaining students technological competence stated in the recent mathematics curriculum. Students with technological competence are required to apply their knowledge and methodology to create solutions for needs and demands (MoNE, 2018). To make students gain this competence, teachers need to design constructivist learning activities through using technology as a partner. This professional development program aims to provide exemplary lesson plans for designing learning materials integrating technology as cognitive tools with a constructivist approach and guide the practitioners in designing such practices. In turn, integration of cognitive tools in mathematics can contribute students' mathematics learning through teachers' effective practices.

Considering the emphasis on continuity, taking actual classroom practices as a basis, creating collaborative and reflective environments for effective professional development, participating in online communities of practice provides a critical opportunity for professional development for teachers in a continuing format in which teachers interact, collaborate, share, reflect and discuss, so it is important to understand complex nature of online participation process that in-service teachers employ. This is significant for both continuous teacher professional development through their career and adaptation to the changing demands of education system. While this is a case study, the findings are expected to provide an example for how to design online community-centered professional development programs about technology integration for in-service teachers. The results of this study intends to indicate how teachers interact and construct knowledge within a professional network and what the impact of this collaboration on their professional development is. These findings can contribute to the design of professional development programs to support novice teachers in different locations who have few opportunities for face-to-face CoP, and create equal opportunities for professional development.

1.5 Definition of Terms

Online professional development program: It refers to a professional development program providing individuals online learning opportunities to improve their competences in their profession through synchronous and asynchronous learning activities.

Community of practice (CoP): It can be defined as people who come together sharing a common goal and practice (Wenger, 1998). Through community of practice, people build a learning partnership based on sharing their practices, learning from each other, and collaboratively learn about a specific topic (Wenger, Trayner, & de Laat, 2011).

Technology integration: It is defined as teachers' practices incorporating technology into their classrooms to support learning and teaching processes (Inan & Lowther, 2010b).

Cognitive tools: "Technologies that enhance the cognitive powers of human beings during thinking, problem solving, and learning" (Jonassen & Reeves, 1996, p. 693).

Constructivist learning environment (CLE): It is an environment in which students use technology as cognitive tools and construct their artifact while they are learning collaboratively.

Synchronous activities: It covers the online activities that allow individuals' interaction in real time.

Asynchronous activities: It covers the online activities that allow individuals to interact with each other or learning materials anytime and anywhere regarding their convenience.

CHAPTER 2

LITERATURE REVIEW

2.1 Teacher Professional Development

2.1.1 Teachers' Professional Development and Social Learning Perspective

With the rapid changes and developments, being an effective teacher in class requires continuous development as well as other occupations do. Being competent in teaching is closely related knowledge about emerging topics, skills to apply them and update the conceptual and craft skills (Cervero, 1988; Guskey, 2000, Long et al., 2019). For continuous development, Corcoran (1995) stated that teachers needed time for collaborative studies with their colleagues, critically examination of the new standards and revision of curricula. With the opportunities for collaboration, critical examination and revision, they can "develop, master and reflect on new approaches" (Corcoran, 1995; p.1). Regarding Vygotskian (1978) notion of social constructivism which emphasizes the social process in knowledge construction (Hull & Saxon, 2009), the essential element in teacher professional development is considered as interaction (Ernest, Catasús, Hampel, Heiser, Murphy & Stickler, 2013). Kellogg (1999) stated that creating a collegial and interactive environment based on authentic activities give chance to solve various complex educational issues. Moreover, studies focusing on teacher collaboration support the significance of teachers' interactions in improving teaching practices and school organizations in terms of their quality and effectiveness (Anderson, 2010; Moolenaar, Daly, & Sleegers, 2011; Schiff, Herzog, Farley- Ripple, & Thum, 2015). Hence, these studies guided teacher professional development studies to focus on teacher collaboration to improve their practices.

The teacher relationships in face-to-face environments were emphasized as a way of improving instructional practice in literature. A recent study indicated that teachers are prone to social learning and it is a promising way for professional development (Meijs, Prinsen & de Laat, 2016). The interactions in their social network led teachers to learn from each other (Moolenaar, 2012). There were studies focusing on interactions within subgroups and the types of interaction which offer learning opportunities (Anderson 2010; Burt 2005). It was stated that the relations between subgroups may affect formal support, mutual help and shared responsibility for student success that are significant factors for achieving learning goals (Penuel, Riel, Joshi, Pearlman, Kim & Frank, 2010). Moreover, several research studies stated that social interactions may have an influence on the environment in which teachers practice their knowledge, engage and experiment new instructional methods (Bryk and Schneider 2002; Daly, Moolenaar, Bolivar & Burke, 2010; Moolenaar, Daly & Sleegers, 2011; Penuel, Fishman, Yamaguchi & Gallagher, 2007).

Teachers have to be an active player when acquiring knowledge through social learning (Mejis, Prinsen & de Laat, 2016). Professional development programs emphasizing active learning, participation and communication between teachers are stated as more effective in improving knowledge and skills (Garet, Porter, Desimone, Birman & Yoon, 2001). If they feel safe, they will not hesitate in trying innovative approaches. Some other studies also revealed that collective questioning of ineffective teaching routines, following new and creative ways of teaching and learning and active engagement leaded to better practice of teaching and learning for professional development (Darling-Hammond & Andree & Richardson & Orphanos, 2009; Grossman & Wineburg & Woolworth, 2001; McLaughlin & Talbert, 2001; Stokes, 2001). In this regard, in order to support teachers' practice on applying new knowledge and skills and making adjustments, professional learning communities serve as a platform for collaboration with their colleagues (Prentice, 2016, Sjoer & Meirink, 2016, Friedrichsen & Barnett 2018).

Existing literature described effective professional development for teachers as continuous, based on actual classroom practices, an environment which gives chances teachers to perform, observe, reflect, receive feedback and collaborate, and consists of reform-type activities (Desimone, Porter, Garet, Yoon &Birman, 2002; Guskey, 2003; Guskey & Yoon, 2009; Ingvarson, Meiers, Beavis, 2005; Lee, 2005). However, the predominant approach in teacher professional development is based on formal courses, workshops or seminars that are provided by external agencies, which gives few opportunities to teachers about how they can deal with the problems in their classrooms (Lieberman & Mace, 2008). Studies in Turkey also indicate that professional development activities in Turkey are mostly based on traditional understanding such as seminars and conferences (Ozoglu, 2010). Similarly, it was noted that teacher professional development practices have long positioned teachers as passive consumers of well-prepared knowledge (Meijs, Prinsen & Laat, 2016). However, the understanding of teacher professional development changes into learning in the workplace and constructing their own professional capital (Hargreaves & Fullan, 2012). Moreover, different studies emphasized the importance of collaborating, exchanging material, sharing experiences about teaching in teachers' professional development (Moolenaar, Sleegers, & Daly, 2012; Thurlings, Evers, & Vermeulen, 2015). Bellibaş and Gümüş (2016) also emphasize that the traditional professional development approaches should be changed into approaches that enable teachers to interact and collaborate through coaching, networking, mentoring and study groups. Therefore, in the light of these studies highlighting the role of social learning in teacher professional development, it can be said that there is a need for investigating a community-based teacher professional development program in terms of its effect on teachers' professional development in Turkey.

2.1.2 Communities of Practice

People who come together sharing a common goal and practice are defined as a community of practice (CoP) (Wenger, 1998). It is explained as a learning partnership in which people benefit from each other's experience of practice, learn from each other, and learn together about a specific topic (Wenger, Trayner, & de

Laat, 2011). Wenger (2004) emphasizes three elements for CoP; these are domain, community, and practice. Domain determines the focus of the members, e.g., mathematics teaching. Community determines the group of people whose domain is relevant, e.g., mathematics teachers. Practice determines the resources that members share and develop together. According to Wenger (1998), there are three principles for an effective CoP: mutual engagement, a joint enterprise, and a shared repertoire. Members of community are engaged in the community for professional development by means of sharing their professional experiences (mutual engagement); are committed to a goal within the professional development process by means of negotiating and renegotiating collectively (joint enterprise) and produce and adapt knowledge by means of sharing their teaching practices, ideas, and experiences (shared repertoire) (Wenger, 1998).

Learning is a social activity and being a part of a CoP shapes members' learning through engagement and participation (Goodyear & Carvalho, 2014). Tsai, Laffey & Hanuscin (2010) stated that:

> One's growth depends on not only changes of feelings and cognition but also the shared values, relationships, networks, and knowledge reproduced in the interaction (p.226)

Regarding the role of social learning in workplaces, community of practice can be considered a solution for professional isolation, which is closely related to networking, tacit knowledge sharing and mentoring as knowledge sharing activities (Cooper & Kurland, 2002). In CoPs, different experience levels, from newcomer to senior fellow are involved (Wenger, 2000). Novice members can gain experience from seniors through their shared experiences. So, seniors have control over the community because of their larger number of connections and they are possibly core members (Wenger, 1998). In this knowledge sharing process, senior members also gain knowledge. Such learning communities growingly construct knowledge resources for the community over time (Lave & Wenger, 1991; Wenger, 2000). There have been examples of CoP studies in different contexts, defense lawyers (Hara, 2000), telecommunication engineers and consultants (Haney, 2003) and teachers (Barab & Squire, 2004). For example, through a face-to-face community of practice model, UK Stroke Service improved their practice in stroke care from the bottom 5% to the top scoring service in four years (Kilbride, Perry, Flatley, Turner & Meyer, 2011).

Learning communities are suggested as a significant and powerful tool for professional development in academic settings considering their ability to transform teaching into a collaborative and empowering endeavor (Hord, 2009; Price, 2005; Smith, 2001). While collaborating and reflecting, professionals elicit and share practical knowledge, work on improving achievement, construct new networks, gain support, and improve communication and sense of community (Kilpatrick, Barrett & Jones, 2003; Palloff & Pratt, 2005; Price, 2005). Although there is an emphasis on teacher collaboration in professional development, Nieto (2003) found that teaching was seen as a solitary craft and there was not any sense of community within teachers. On the other hand, developing community-centered professional support for in-service teachers has been considered as one of the greatest ways to transform educational systems (Kaul, Aksela & Wu, 2018). Hence, creating an environment where a sense of community exists, and learning occurs within the community gains significance. For a CoP that has an impact on teachers, it is suggested to be based on teachers' experiences, practices, and evaluation (Supovitz & Christman, 2005). As teachers share their expertise in a community, they create new understandings about instruction and content (Little, 2003; Stoll, Bolam, Mcahon, Wallace & Thomas, 2006). Working collaboratively on teaching provides opportunities to pose problems, challenges, and articulate practice (Horn & Kane, 2015). The studies indicated that the teachers who take part in professional learning communities improved their lesson design skills that can affect student learning (Tan, Chue & Teo, 2016; Lee, 2015). Hence, these studies highlighted the significance of community of practices as a way of transforming teachers' practices. Considering the integration of cognitive tools as a new method in teachers' technology integration practices, a community of practice for teacher professional development can be investigated to examine how it transforms teachers' opinions and practices in this regard.

2.1.3 Online Communities of Practice

Recently, virtual professional learning communities have increased their popularity in the literature (Stryker, 2012). In online learning environments, teachers are provided authentic, flexible, and personalized opportunities which allow interaction and communication with their colleagues (Chieu & Herbst, 2016; Duncan-Howell, 2010). Technology offers learning communities interact through online platforms to facilitate professional development (Hord, 2009; Lock, 2006; Wenger & Snyder, 2000). With the increase in use of online platforms, "new paradigms of learning that accompany the continuing expansion of the Internet, online learning, and online learning relationships" come to the fore (Haythornthwaite & Andrews, 2011, p. 2). With these advances in technology, the way, the time and the location of learning and the creation of content of learning have changed (Paulin & Haythornthwaite, 2016). In business, a systematic review indicated that allowing employees to collaborate and share knowledge within communities which supports each employee mostly in both face-to-face and online environments decreases cost and increases innovation (Grimshaw, Nielsen, Judd, Coyte & Graham, 2009). The opportunities of connecting people not located in the same place at the same time and creating networks of people with common interests without time and space limitations can be considered as the main driver for virtual communities of practice (Barnett, Jones, Bennett, Iverson, & Bonney, 2012). Virtual communities of practice have been implemented by companies such as HP, Xerox and Caterpillar to create an environment to share knowledge online (Ardichvili, Maurer, Li, Wentling, & Stuedemann, 2006). Recently, entrepreneurs' engagement and learning in an online community of practice environment has been studied (Hafeez, Foroudi, Nguyen, Gupta & Alghatas, 2018).

In education, several studies stated that learning through online discussions provides teachers authentic, flexible and personalized opportunities which help them to interact with each other (Chieu & Herbst, 2016; Duncan-Howell, 2010) and share resources and develop their pedagogical skills and strategies (Chen, Chen & Tsai, 2009). Moreover, Baran and Cagiltay's study (2006) indicated that teachers prefer online professional development programs if they are interactive, highly practical and based on problem-solving and collegial learning. Recently, there has been lots of teachers' online learning communities which were built through online tools, course management systems and virtual learning environments such as Moodle (Zhang, Liu & Wang, 2017). Listservs, blogs, wikis, social networking sites, and discussion forums are often used platforms for online CoPs (Trust & Horrocks, 2017) whereas use of instant messaging services like WhatsApp has become a new means of facilitating professional tasks (Pacholek et al., 2021). In such online learning environments, teachers can discuss their practices in the classroom related to an approach and decide to use it in his/her own classroom (Chen et al, 2009; Kent, Laslo & Rafaeli, 2016). Also, they can construct knowledge collaboratively along with sharing their educational experiences by means of developing effective social interactions (Chen et al, 2009; Hou, 2015). Participating in online discussion leads learners to collaborative knowledge-building processes and makes them become reflective, think critically, and understand concepts better than the ones studying alone (Hew & Chung, 2013).

In the examples of continuous and collaborative professional development programs about technology integration indicated that scheduling a meeting was a challenge for teachers (Khalif, Gok & Kouraïchi, 2019; Cober, Tan, Slotta, So & Könüngs, 2015; Kali et al, 2015). At this point, designing effective online collaborative and continuous teacher professional development programs can provide a solution. Considering the potential of online learning, online professional learning communities (PLCs) have been studied as a way of teachers' learning and professional development (Prestridge, 2010; Kao, Tsai & Shih, 2014). Online CoPs provide opportunities as accessing all members easily, ability to work together, involving activities, interacting through exchanging information and experiences (Dubé, Bourhis & Jacob, 2005). Moreover, online CoPs allow participants to overcome location barriers (Hajisoteriou, Karousiou & Angelides, 2018). The interactivity in online CoPs is based on the collaboration among teachers in which they acquire new ideas and redefine their own knowledge structures by developing new efficient practices (Hur & Brush, 2009). According to the research, teachers' work is improved by engagement in communities which allows members to develop teaching skills and strategies (Chen, Chen & Tsai, 2009). A recent study also supported the role of online CoPs in decreasing the isolation of teachers and promoting reflection and collaboration, which may lead to improvement in teachers' pedagogical and content knowledge (Boada, 2022).

Many researchers emphasize that if teacher professional development activities evolved from short-term workshops or seminars to long-term collaborative communities, the benefits of professional development activities will evolve from individual to collective dimension in relation to understanding and adapting to the innovations and educational reforms (Lieberman & Pointer Mace, 2010; Petty, Heafner, Farinde, & Plaisance, 2015; Trust, 2012; Vangrieken et al., 2017). Similarly, learning communities play a critical role in enhancing the overall performance of schools along with contribution to the reform efforts (Friedrichsen & Barnett, 2018; Pang et al., 2016). Programs in which teachers take place in professional communities indicate that there is evidence for changes in local knowledge, the exploration of solutions to problems and practices in particular contexts (Katz & Earl, 2006; Lieberman & Wood, 2002a; O'Brien, Varga-Atkins, Burton, Campbell & Qualter, 2008). Furthermore, learning within professional communities provides critical chances for professional development (Gellert, 2003; Lieberman & Wood, 2002b). Thus, it can be said that studying the impact of an online CoP can contribute to the design of long-term collaborative professional development programs to support novice teachers in different locations who have few opportunities for face-to-face CoP and create equal opportunities for professional development by decreasing teacher isolation and forming a sense of professional identity (Clarke, 2009; Hramiak, 2010; Trent & Shroff, 2013).

Synder, Wenger and Briggs (2004) state the principles that should be considered when implementing online CoPs as the participation with the aim to learn something new, the duration of CoP, the knowledge sharing, the interaction and discussion on professional practices, the flow of information, the innovation of the community, the enthusiasm of the members for participation, the flexibility and the value of the community as a way of professional development. The researcher takes these principles in consideration while designing the activities within the online CoP, identifying its participants, and the duration of the program.

2.1.4 Knowledge Construction Through Social Interaction

According to Vygotsky (1978, 1986), shared knowledge and meaning are negotiated and constructed collaboratively in socially mediated learning environments. Although Vygotsky provided a basis for social constructivism as a theory of learning, rather than theory of instruction, social constructivist theory provides premises for how to create a social constructivist learning environment (Hull & Saxon, 2009). Regarding the fact that interaction with a more competent peer leads to cognitive development (Tudge, 1990), socially constructed learning occurs in dialectical exchange between peers in online learning environments (Hull & Saxon, 2009). Hull et al. (2009) also state the role of learning activities and assignments in online constructive social interaction. In online learning environments, it is significant that online discussions should lead to knowledge construction (Garrison & Cleveland-Innes 2005; Dennen & Wieland 2007). To construct knowledge during interactions in online discussion, it is necessary for learners to exchange their ideas, explore their contradictory perspectives, and negotiate their inferences (De Laat & Lally 2003; Dunlap 2005). There are studies showing that teachers learn more through drawing on the expertise of their peers and others than through formal activities (Boud & Hager, 2012). Campbell and Macdonald (2011) state that their study was a successful online professional development example in which participants could reflect together with a community of peers and this reflection opportunity could have a significant effect on building confidence and leading to new ideas for practice. In the light of previous studies, exploring the collaborative knowledge construction of teachers through their interactions in an online CoP can reveal their learning processes in-depth.

Table 2.1.1 Phase hierarchy and indicators for analysis within each phase of interaction that leads to negotiation of meaning (Gunawardena et al. 1997)

Phase I: Sharing/comparing of information	A. A statement of observation or opinion B. A statement of agreement from one or more other participants C. Corroborating examples provided by one or more participants D. Asking and answering questions to clarify details of statements E. Definition, description, or identification of a problem
Phase II: The discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements	A. Identifying and stating areas of disagreement B. Asking and answering questions to clarify the source and extent of disagreement C. Restating the participant's position, and possibly advancing arguments or considerations in its support by references to the participant's experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view
Phase III: Negotiation of meaning/co-construction of knowledge	A. Negotiation or clarification of the meaning of terms B. Negotiation of the relative weight to be assigned to types of argument C. Identification of areas of agreement or overlap among conflicting concepts D. Proposal and negotiation of new statements embodying compromise, co-construction E. Proposal of integrating or accommodating metaphors or analogies
Phase IV: Testing and modification of proposed synthesis or co-construction	A. Testing the proposed synthesis against ''received fact" as shared by the participants and/or their culture B. Testing against existing cognitive schema C. Testing against personal experience D. Testing against formal data collected E. Testing against contradictory testimony in the literature
Phase V: Agreement statement(s)/application of newly constructed meaning	A. Summarization of agreement(s) B. Applications of new knowledge C. Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the conference interaction

To measure the level of knowledge construction in online discussions, interaction analysis model (IAM) has been widely used (Gunawardena, Lowe & Anderson, 1997). Gunawardena et al. (1997) produce a model by grounded theory principles and this model examines the higher and lower functioning as stated by Vygotsky in the social construction of knowledge and negotiation of meaning. The model divides knowledge construction into five phases: Phase I: Sharing/Comparing, Phase II: Dissonance, Phase III: Negotiation/Co-construction, Phase IV: Testing tentative constructions, and Phase V: Statement/Application of newly constructed knowledge. In Phase I, learners' posts are related to giving information as a response to a question. In Phase II, when learners explore inconsistency between their own ideas and others' ideas, the dissonance occurs in their posts. In Phase III, they negotiate the meaning. In Phase IV, they test and modify their proposed synthesis or co-construct their meaning. Finally, in Phase V, they agree or apply newly constructed meaning (Table 2.1.1).

2.1.5 Designing Teacher Professional Development Program

Designing the program of a teacher professional development is closely related with instructional design (ID). It is defined as a process which eases planning in education and managing the systems (Hardré, 2003; Reiser, 2002). Learning theories, the settings, age, content needed, and levels of participants shape the principles of ID (Reigeluth, 1999). Traditional ID models which are also called micro-level design models consist of analysis, design, development, implementation, and evaluation (ADDIE) steps (Gustafson & Branch, 2003). These models deal with developing a lesson, unit or course. In the analysis step, learning problems, goals, needs and prior knowledge are identified. In the design step, specific learning outcomes, content and the media are considered. In the development step, instructional materials are developed. In the implementation step, the designed and developed program is applied. Finally, in the evaluation step, data is collected throughout the program and at the end of the program.

For constructivist learning environments, Jonassen and Rohrer-Murphy (1999) argued that activity theory can provide a framework for analyzing needs, tasks and outcomes since it is in line with constructivism, situated learning, distributed cognitions, case-based reasoning, social cognition and everyday cognition that underlie constructivist learning environments (Jonassen & Land, 1999). Although community of practice framework, which is based on how learning occurs in socially situated activities, facilitates the understanding of the community as a whole and how members construct their common knowledge and their own identities, determining analytical units for connecting the individuals to the community activity system can be seen in Cultural-Historical Activity Theory (CHAT) (Michos & Hernández-Lea, 2018). Moreover, Grifford and Enyedy (1999) stated activity theory as an appropriate framework for knowledge construction in computer-based collaborative learning activities. The characteristics of collaborative activities and how participants engage in social interactions through online environments can be established by activity theory (Hashim & Jones, 2007).

CHAT is based on sociocultural theories of Luria, Leont'ev, and Vygotsky, who stated that the content and the process of thinking occur in relationship to others, rather than in isolation within one person's mind (Cole & Engeström, 1993). According to Engeström (2001), an activity consists of subject, community, rules, division of labour, mediating tools, object and outcome as it can be seen in Figure 1. It focuses on "the activities in which people are engaged, the nature of tools they use in those activities, the social and contextual relationships among collaborators in those activities, the goals and intentions of those activities, and the objects or outcomes of those activities" (Jonassen & Rohrer-Murphy, 1999, p.68). Cultural Historical Activity Theory (CHAT) emphasizes social context, environment and history in shaping experiences (Cole & Engeström, 1993; Roth & Lee, 2007). The theory explains learning as a process integrated with social, cultural, and historical contexts (Anderson & Stillman 2013; Cole & Engeström 1993). While designing constructivist learning environments with activity theory framework, six steps are stated (Jonassen & Rohrer-Murphy, 1999). First one is clarifying the purpose of the activity system which helps to see participants' expectations, goals, motives and understand the context. Second one is analyzing the activity system in which the components of activity system examined in detail, such as subject, object, community, rules, division of labor. Thirdly, the activity structure is analyzed through defining the activity and decomposing the activity to its component actions and operations. Fourthly, tools and mediators which provide the interaction between subject, object and community are analyzed. Fifthly, the context is analyzed by determining internal/subject-driven contextual bounds and external/community-driven contextual bounds. The last step is analyzing the activity system dynamics by assessing how components affect each other. The activity system in this study was the collaborative work of elementary mathematics teachers within a CoP, using tools such as lesson plans to achieve the object of learning how to design their lessons by integrating technology as cognitive tools with constructivist approaches to promote meaningful learning.

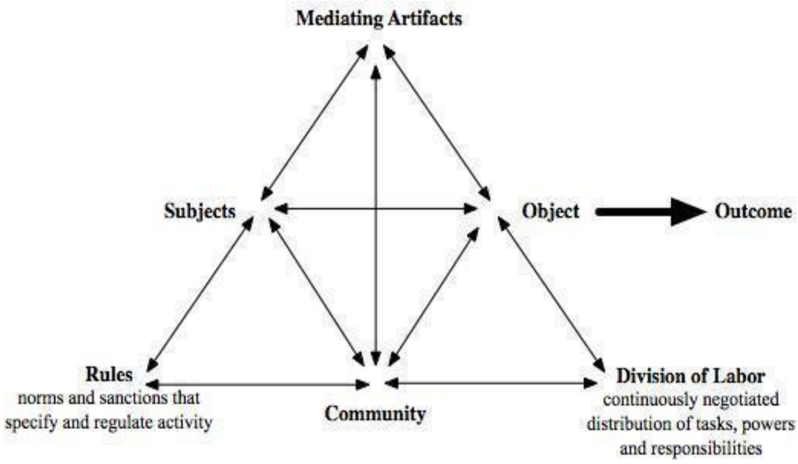


Figure 1 The components of Engöstrom’s cultural historical activity theory

2.2 The Integration of Information Communication Technologies (ICTs) in Education

2.2.1 The Role of Information Communication Technologies (ICTs) in Mathematics Education

Considering mathematical competence as only related to procedures and concepts that can be gained with practice is stated as naïve and incomplete by Contreras (2014). On the other hand, the idea that mathematics education is based on memorization and execution of procedures and these procedures always lead to unique and unquestioned right answers still remains (Ernest, 1997; Hoyles, 2016; Maaß & Artigue, 2013; Schoenfeld, 1992, 2004). This leads to a behaviorist approach with an emphasis on formal, abstract mathematics remaining prevalent in many countries (Maaß & Artigue, 2013; Ozdamli, Karabey & Nizamoglu, 2013). This didactic approach creates motivation and engagement issues in the learning process (Boaler, 1993; Hoyles, 2016). Technology can provide opportunities for better understanding and concretize the mathematical concepts in which students have difficulties. The Common Core State standards Initiative (2011) underlines the role of students' use of technological tools in order to explore and deepen their understanding of mathematics concepts. Moreover, there are studies supporting that the integration of technology in teaching mathematics helps learners to visualize and understand mathematical concepts rather than memorize complex and abstract topics (Kaleli Yılmaz, Ertem & Güven, 2010).

While the role of technology in mathematics education is highlighted, studies show that mathematics teachers mainly adopted learning from technology approach and occasionally learning with technology approach (Tay, Lim, Lim & Koh; 2012). Teachers' use of technology is limited. For instance, teachers used interactive whiteboards rarely as a way of promoting deep learning and higher-order thinking although they have been used for several years (Whyburn & Way, 2012). Urbina and Polly's study (2017) also indicated that teachers who used technology in their mathematics classes, only used technology rarely or used as a way for low-level review of mathematical computation or as an activity when students finished their activities early. Many studies indicate that technology is under-utilized in mathematics education (Becker & Ravitz, 2001; Conlon & Simpson, 2003; Cuban, 2001). Adopting technology as a learn-from medium, such as watching a YouTube video, reading information on a web site, yields insufficient results in student achievement (Cuban, 2001; Kim & Reeves, 2007; Tamim, Bernard, Borokhovski, Abrami & Schmid, 2011).

While the use of technology as an add-on instrument continues, the integration of ICTs is suggested to be applied through various teaching methods and approaches, especially constructivist approaches (Fu, 2013; Xavier, Tina, Matti & Inocente, 2018). The positive effect of ICTs on student achievement is apparent when students work on student-centered activities collaboratively (Becker & Ravitz, 2001; Carter & Smith, 2001; Li & Ma, 2010; Shapley, Sheehan, Maloney, & Caranikas-Walker, 2011). Creating a student-centered learning environment that integrates ICTs changes the traditional passive recipient-role of students to active players of their own learning (Xavier et al., 2018). Moreover, use of ICT contributes to students' production of knowledge (Becta, 2003). This indicates that ICT is aligned with constructivist perspective where students explore and make meaning of mathematical concepts (Kreijins, Vermeulen, Kirschner, van Buuren & van Acker, 2013). Similarly, the Turkish mathematics curricula (MoNE, 2018) emphasized a constructivist approach where students are active learners who solve problems, relate mathematics with daily life and understand mathematical concepts through discovery. Moreover, the role of ICTs was highlighted that students should be able to apply their knowledge and methodology to create solutions for needs and demands by means of ICTs (MoNE, 2018). Constructivist learning environments integrating ICTs is suggested through the curriculum to gain students ICT competency. In addition, the close link between ICT and mathematics emphasized and leaded to an interdisciplinary approach to teach mathematics and ICT (Jehlička & Rejsek, 2018).

According to TIMSS (Trends in International Mathematics and Science Study) results, the mathematics scores of Turkish students has been below international scores over years (Sarı, Arıkan & Yıldızlı, 2017). Considering the mathematics results in international and national examinations, there is a clear need for effective professional development strategies to support elementary mathematics teachers in Turkey and in turn, student achievement in mathematics. Similarly, the Common Core State Standards Initiative (2011) underlines the role of students' use of technological tools in order to explore and deepen their understanding of mathematics concepts. Kitchen and Berk (2016) indicated that the use of cognitive tools in mathematics education enhances students' reasoning through problem solving and discourse in reforms in mathematics education. Hence, integrating cognitive tools into mathematics classes can make a difference in students' mathematics learning through teachers' effective technology integration. At this point, searching for the effect of an online community based professional development about integration of cognitive tools can have potential contributions to mathematics education by revealing teachers’ gains from the program and opinions about integration of technology as cognitive tools.

2.2.2 The Integration of Information Communication Technologies (ICTs) in Mathematics Teacher Education

The knowledge, skills and actions of mathematics teachers were discussed as a consequence of their experiences in pre-service and in-service mathematics teacher education (Leong, Kaur, & Kwon, 2017). Thus, the integration of ICTs in mathematics classes is also determined by the opportunities teachers have during their mathematics teacher education and professional lives as teachers. The research studies suggested that lack of knowledge, skills and self-efficacy can limit the use of technology in classroom (Hechter &Vermette, 2013, Hew & Brush, 2007; Inan & Lowther, 2010a; Kopcha, 2012). Similarly, many studies emphasized the mathematics teachers’ lack of knowledge and skills for using technology in their teaching practices (Erbaş, Çakıroğlu, Aydın, & Beşer, 2006; Çakıroğlu, Güven, & Akkan, 2008; Bozkurt, Bindak & Demir, 2010; Kaleli Yılmaz, 2015; Birgin, Uzun & Mazman-Akar, 2020). Moreover, once teachers struggle with the use of technology, they have tendency not to integrate technology in their practices (Ayvacı, Bakırcı, & Başak, 2014; Kaplan, Öztürk, Doruk, & Duran, 2016). Regarding the literature in the factors influencing the use of technology in lessons, Güven and Kaleli Yılmaz (2016) suggested to work on the inner factors such as attitude, self-reliance, belief rather than the outer factors such as school conditions, administration support and technology availability to prepare teachers to teach using ICT effectively. Hence, in order to influence the inner factors for integrating technology, teacher education programs for pre-service teachers and professional development programs for in-service teachers have critical roles.

Based on the need of training well-equipped teachers in the use of ICT, some changes were made in the courses of teacher education programs in Turkey (YÖK, 2007). The number of courses involving ICTs was increased and teacher candidates started to take more courses such as Basic Computer Skills, Instructional Technologies and Material Development, Computer Assisted Instruction. In this regard, a recent study investigating the perceived ICT proficiency of Turkish mathematics teachers indicated that teachers with 1-5 years of teaching experience were more proficient than other teachers with higher teaching experience (Birgin, Uzun & Mazman-Akar, 2020). Birgin et al. (2020) associated this finding with more chance to learn and practice ICTs due to the change in teacher education programs. On the other hand, the result of this study indicated that Turkish mathematics teachers have insufficient knowledge and experience in the integration of ICTs into their classes (Birgin et al., 2020). A study about the technology integration courses in teacher education programs stated that the lesson time and content of the courses aiming to develop teachers' technology integration skills was insufficient (Canbazoğlu-Bilici, Yamak, Kavak, & Guzey, 2013). Moreover, Yiğit-Koyunkaya's study (2017) which examines pre-service secondary mathematics teachers' knowledge levels and knowledge development of technological pedagogical content knowledge through a teaching experiment methodology found that pre-service teachers comprehend technology integration as using smartphones, smartboards, projector, and presenting with PowerPoint before the experiment. However, their understanding changed into the appropriate integration of technology in their lesson plans after the teaching experiment (Yiğit-Koyunkaya, 2017). This indicates the significance of technology integrated or technology-based courses in teacher education programs. In addition, many researchers also emphasized the role of integrating technology into courses in education faculties and implementing technology assisted course models for raising teachers as effective technology users in their teaching practices (Akkoç, 2012, 2013; Akyüz, 2016; Bowers & Stephens, 2011; Koehler & Mishra, 2008). Regarding the teacher education programs' role in technology integration in the professional life, another study indicated that the level of opportunities that pre-service teachers have about practicing technology integration in real classroom environments determined their uses of technology as beginning teachers (Tondeur, Pareja Roblin, van Braak, Voogt, & Prestridge, 2016).

Considering both the change in teacher education programs and the use of technology in the recent age, beginning teachers are considered as more effective users of technology in their classes. While they are recognized as digital natives who have tendency to use technology based on their knowledge, beliefs, and attitudes towards technology (Bate, 2010; Starkey, 2010), there have been various results considering the effective use of technology by beginning teachers (Slaouti & Barton, 2007; Tondeur, Pareja Roblin, van Braak, Voogt, & Prestridge, 2016). The studies indicated that beginning teachers should be supported in their uses of technology by encouraging school policies about technology integration, promoting self-efficacy, and endorsing the contributions of the teachers, and creating opportunities for discussions about technology with experienced teachers (Starkey, 2010; Slaouti & Barton, 2007). With a similar perspective, Baya'a, Daher and Anabousy (2019) studied the development of in-service mathematics teachers' integration of ICT within a community of practice in Israel. The study involved pre-service teachers that were practicing the integration of ICT in mathematics classes. The in-service mathematics teachers mentored the pre-service teachers through designing a lesson plan integrating ICT and implementing the lesson plan together. The results indicated that in-service teachers improved their technological pedagogical content knowledge and experiences in the integration of ICT in their teaching practices through the collaboration with pre-service teachers. This can be seen as a good example for supporting both in-service teachers and pre-service teachers in the integration of ICT through a community of practice.

In general, the professional development programs create opportunities for teachers to learn how to integrate technology in their teaching practices. However, Aslan and Zhu (2018) emphasized that the change in teachers' beliefs about using ICTs in teaching occurs by teachers' studying ICT skills on their subject courses. Similarly, in another study, Turkish teachers also mentioned the ICT tool focus of the teacher trainings about technology integration and the lack of relating ICT with the subjects as a problem (Unal & Ozturk, 2012). Hence, teachers can work on the pedagogic aspect of ICTs which is known as more critical in the literature (Hughes, 2005; Hew & Brush, 2007; Akkoç, Özmantar, & Bingölbali, 2008; Harris, Mishra, & Koehler, 2009). For example, a recent study exploring the influence of technology integrated professional development course on Turkish mathematics teachers indicated that the professional development program affected teachers' beliefs about the use of technology and constructivist ideas in their practices positively (Kul, 2018). The study focused on Geogebra as a tool and mathematics teachers studied how to use Geogebra in their mathematics teaching. Moreover, there are other studies showing the positive effect of professional development programs on mathematics teachers' use of Geogebra in Turkey (Baltaci, Yildiz & Kosa, 2015; Horzum & Unlu, 2017; Kaleli Yilmaz, 2015). Birgin and colleagues (2020) also suggested to organize practice-oriented and interactive periodical trainings for the use of ICTs in mathematics teaching. Another study emphasized that teachers should understand how to position technology and how to align technology with specific mathematics learning objectives (McCulloch, Hollebrands, Lee, Harrison & Mutlu, 2018). Hence, the relevant literature underlines the significance of the subject focus while learning to integrate ICTs in teaching practices.

2.3 Theoretical Framework for Learning and Instruction

2.3.1 Constructivism and Constructionism

Designing constructivist learning environments in which students use technology as cognitive tools and construct their artifact while they are learning were closely associated with two learning theories: constructivism and constructionism.

Constructivism has been studied by Jean Piaget in twentieth century. He confronted the idea of explaining knowledge as a simple transmission from teacher to student and supported that the student has actively constructed his/her knowledge and meaning from an interaction between his/her ideas and experiences (Piaget, 1968). Learners have an active role in building their own understanding. Cornu and Peters (2005) stated that knowledge cannot be considered as fixed and separate from the learner, rather construction of knowledge is based on accommodating and adapting according to new experiences or ideas. In addition, constructivism addresses children’s learning at different stages of intellectual development (sensory-motor, pre-operational, concrete operational and formal operations) and the processes of learning in which learners encounter new information with sensory data and use this to construct new knowledge and meanings (Pritchard & Woollard, 2010).

Constructionism has been studied by Seymour Papert of the MIT Media Lab. Papert’s theory of constructionism is developed from Piagetian constructivism, but constructionism adds the emphasis on learners’ designing or building an artifact which can be reflected upon and shared with others (Papert, 1991). He explained constructionism as follows:

> *Constructionism—the N word as opposed to the V word—shares constructivism’s connotation of learning as “building knowledge structures” irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it’s a sand castle on the beach or a theory of the universe (Papert, 1991, p.1).*

Constructionism also highlights the co-creation of knowledge through interacting with others within a particular community as well as interacting with his/her own experiences and ideas (Jha, 2012). The significance of tools, media, and context stands out in Papert’s constructionism (Ackerman, 2001; Kafai & Resnick, 2012). Accordingly, aiming to help students’ learning process, educational, computing, and communication tools can be used as tools, teachers can take advantage of various media, and students can be given a learning context.

Rob and Rob (2018) reviewed existing literature and highlighted the difference between constructivism and constructionism. They explained a constructivist teacher’s role as setting up a learning environment in which students learn individually through solving a problem and produce an individual artifact without further support from the teacher. On the other hand, they stated a constructionist teacher’s role as setting up a learning environment in which students learn collaboratively through solving a problem and produce an artifact with guidance from the teacher. Constructivism positioned teachers as initiators while constructionism positioned them as facilitators in the learning environments (Rob & Rob, 2018). In this study, while constructivism provides a foundation for Papert's constructionism, constructionism provides a foundation for Jonassen's designing constructivist learning environments.

2.3.2 Designing Constructivist Learning Environments

While participating in this online CoP, teachers focus on how to integrate a cognitive tool in mathematics lessons within a constructivist learning environment. Jonassen's model for designing constructivist learning environments (CLEs) (1999) to engage students in knowledge construction constitutes a framework for this study. The model, as shown in Figure 2, consists of six essential elements. First element at the center of the model is a problem, question, or a project. In a constructivist learning environment, students aim to interpret and solve a problem. While students are trying to find out the fundamental and significant elements of the problem, they are expected to design and build the end product (Liu, 2003). Similar to problem-based learning, students work on an ill-structured problem that includes a challenge that directly ties a significant problem to one that affects them on a daily basis. This connection adds on an essential motivating element to the students' problem-solving activities (Delisle, 1997). The problem helps students work on a problem collaboratively to create a solution in conjunction with existing knowledge and newly-gathered knowledge (Moallem, 2019) and place them as active problem-solvers (Hmelo-Silver, 2004; Kuvac & Koc, 2019) by enhancing their creative thinking skills (Abdillah, Mastuti, & Rahman, 2018). Second element is related cases or worked examples to help students to understand the problem and possible solutions. Related cases may aim to enhance cognitive flexibility which allows learners to switch between various tasks and goals (Buttelmann, Karbach, & Bastian, 2017). Moreover, related cases may contribute case-based reasoning through leading students to look for existing cases and use them as references and construct their knowledge and solution strategies accordingly (Sharma & Land, 2019). Third element is information sources to support students. Since students were active players in constructivist learning environments (Xavier et al., 2018), they were provided relevant information resources. Fourth element is cognitive tools that help the interpretation and manipulation of the problem. With the help of cognitive tools, students are involved in critical thinking, knowledge representation, and meaning-making processes (Ge et al., 2019; Jonassen, 1995). Fifth one is conversation and collaboration tools for negotiation and co-construction of the meaning among students. Constructivist learning environments require students' interaction and discussion through studying in groups rather than clinging to only one way of consideration (Steketee, 2002). In this environments, students co-construct knowledge and involve in in-depth discussions productively during solving the problems (Hmelo-Silver & Barrows, 2006; Ertmer & Glazewski, 2019). Sixth one is social/contextual support systems for the implementation of CLEs (Jonassen, 1999). The contextual factors such as convenience of time for designing and implementing, culture of the organization, and teacher professional development have an impact on the success of technology-integrated classes (Stein, Remillard, & Smith, 2007). Moreover, support mechanisms for students' readiness are critical for students' learning with technology (Lai & Hwang, 2015).

Students mainly perform learning activities that require exploration, articulation, and reflection in CLEs, and these activities require instructional activities such as modeling, coaching, and scaffolding. For integrating cognitive tools in constructivist learning environments, "…teachers must be comfortable with a constructivist or project-based, problem-solving approach to learning; they must be willing to tolerate students' progressing independently and widely varying paces; they must trust students to sometimes know more than they do and to take on the role of expert teacher… and they must be flexible enough to change directions when technical glitches occur" (Foa, Schwab, & Johnson, 1996, p. 52). Similarly, many studies highlighted the support need of students while they were collaboratively developing a product in a constructivist learning environment (Kafai, Ching & Marshall, 1997; Yıldırım, 2004). Modeling help students see how to do or think to solve similar problems. When teachers model a performance, students can learn how to relate problem aspects to their own personal knowledge (Jonassen, 1997). Teachers take the role of a coach as helping them not give up and lose their interest during the struggles that may come up with ill-structured problem solving (Ma & Williams, 2013) and guiding them to involve in meta-level reflections to construct knowledge through argumentation (Talaue, Kim, & Aik-Ling, 2015). On the other hand, teachers provide scaffolding at the right time to support them through their thinking and problem-solving process (Üçgül, 2012).

Jonassen (1999) also states guidelines for teachers to design constructivist learning environments are as follows:

1. Select an appropriate problem for the learning focus on
2. Provide related cases or worked examples to enable case-based reasoning and enhance cognitive flexibility
3. Provide learner-selectable information just-in time
4. Provide cognitive tools that scaffold required skills
5. Provide conversation and collaboration tools
6. Provide social/contextual support for the learning environment

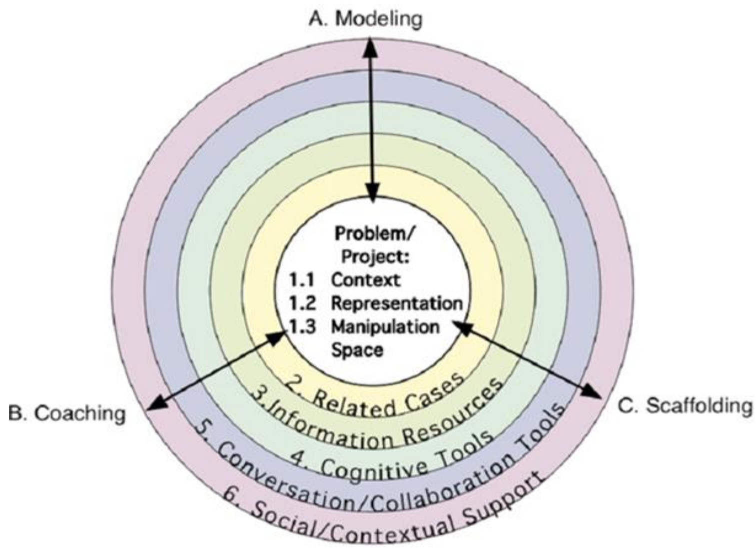


Figure 2 Model for designing CLEs (Jonassen, 1999, p. 218)

2.3.3 Cognitive Flexibility

Cognitive flexibility was defined as "the ability to spontaneously restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands" (Spiro, Feltovich, Jacobson, & Coulson, 1988, p. 35). It contains identifying and applying suitable information, so, comprehending the case and making decisions (Spiro et al., 1988). It is considered as the capacity to come up alternative solutions and shift perspectives (Stevens, 2009). In other words, it allows students to shift between different tasks and goals (Buttelmann, Karbach, & Bastian, 2017). Hence, cognitive flexibility allows individuals to handle novel and difficult situations and create alternative strategies (Stahl & Pry, 2005).

Cognitive flexibility theory with its constructivist approach takes part in Jonassen's Designing CLEs Model (1999), which is the focus of the teacher professional development program in this study. The second element of the model, which is related cases, aims to enhance cognitive flexibility of the learners during an ill-structured problem solving. According to Spiro and DeSchryver (2008) ill-structured domain varies significantly across the contexts in which knowledge is to be applied, lacks consistency in terminology between instances, and resists efforts to define prerequisites for knowledge application. For instance, the application of bridge construction regarding various geographical features and regulations of the related area requires more complex approach than applying a memorized strategy (Balcytiene, 1999; Spiro, Feltovich, Jacobson, & Coulson, 1991; Spiro & Jehng, 1990). Considering the central role of the ill-structured problems in constructivist learning environments, the students need to apply what they know to the novel situations, which enhances their cognitive flexibility.

Cognitive flexibility theory suggests that oversimplification of the complex knowledge to be taught leads to not being able to transfer knowledge to new and different domains (Spiro & Jehng, 1990). Hence, the traditional understanding relying on just "prepackaged prescriptions for how to think and act" did not help students solve complex real-world tasks (Spiro, Collins, Thota, & Feltovich, 2003). Instead, Spiro and his colleagues (2003, p.8) stated:

> "To function in today's world, one must be able to independently assemble elements of prior knowledge acquired at different times and for different purposes into a 'schema of the moment' that fits a new situation - a new problem, case, text- one is facing."

In order to develop students' cognitive flexibility, the learners are required to approach the same information in variety of ways and for multiple purposes in flexible learning environments (Spiro et al., 1992; Spiro & Jehng, 1990). Similarly, ill-structured problem solving within constructivist learning environments provide learners an environment in which learners follow different solution paths without just applying the general rules and principles (Jonassen, 1997).

Moreover, Jonassen's Designing CLEs Model (1999) stated that students learning can be supported with related cases through case-based reasoning. Case-based reasoning discusses that knowledge is stored as stories about experiences and situations (Schank, 1990). Hence, when individuals encounter a novel situation that they do not comprehend, similar situations help them understand (Jonassen, 1999). Case studies assisted students in understanding how variables are used in the given context in a problem-based learning setting, which enhances knowledge construction (Ertmer & Koehler, 2014; Hmelo-Silver, 2013). Resolving several situations over time creates a case library (Tawfik & Kolodner, 2016) and this case collection encourages students to use these experiences as a resource and base their learning and problem-solving techniques on these instances (Sharma & Land, 2019). In this method, the memory of the students is reinforced by bringing to mind a comparable situation from which they might learn how to solve the current issue, and this enhances their cognitive flexibility. Making case libraries available to students can contribute to cognitive flexibility while also aiding in the generation of ideas and solutions (Kolodner, Hmelo, & Narayanan, 1996).

2.3.4 Cognitive Tools

The cognitive tool as a term has been used in different meanings correlating with different theories through its history. A systematic review (Pakdaman-Savoji, Nesbit & Gajdamaschko, 2019) indicated that the cognitive tool concept had been associated with cognitive development by Vygotsky (1930/1999), computer technologies by Pea (1985), distributed cognition by Salomon (1993) and constructivism by Jonassen (1995). While Vygotsky (1930/1999) mentioned cognitive tools as cultural tools supporting learners' mental development, Pea (1985) stated the role of cognitive tools in supporting learners' cognitive reorganization. Salomon, Perkins, and Globerson (1991) highlighted that cognitive tools could support learners about engaging higher levels of cognitive processes than the ones learners perform without the cognitive tools. On the other hand, Jonassen (1995) discussed the significance of cognitive tools in constructivist learning.

According to Jonassen (1996), the cognitive tools are defined as intellectual partners for learners to support their critical thinking and higher-order learning. Considering the use of cognitive tools, student-led learning activities and the role of students as designers are underlined (Jonassen, Carr, & Yueh, 1998). Jonassen and his colleagues discussed that students could take greater advantage from cognitive tools by using them for designing and building new artefacts rather than using them for consuming (Jonassen et al., 1998). On the other hand, student-centered learning theorists embrace cognitive tools as instruments for managing the cognitive load in open learning environments and reducing the task complexity (Iiyoshi, Hannafin & Wang, 2005). Iiyoshi and Hannafin (1998) grouped the cognitive tools in student-centered learning environments based on their functions: information seeking, information presentation, knowledge organization, knowledge integration and knowledge generation. For information seeking, cognitive tools such as keyword search and special purpose searching tools are used to identify, locate, and retrieve relevant information. For information presentation, visualization tools and textual or conceptual maps are used to select and represent the relevant information. For knowledge organization, linking tools, notebook tools and outline processors are used to structure, simplify, and manipulate information. For knowledge integration, simulation tools, knowledge maps and elaboration tools are used to relate the new knowledge with the existing knowledge and help to test the relationships. For knowledge generation, template tools and presentation generation tools are used to lead knowledge generation, manipulation, and representation.

The literature about cognitive tools indicated the use of the term had varied based on the interpretation so it is suggested that the definition of cognitive tools embraced in the study should have been stated (Pakdaman-Savoji et al, 2019). While many researchers underlined the role of cognitive tools as amplifying cognitive functioning, facilitating the generation of knowledge and scaffolding performance through meaningful, authentic, and complex learning tasks (Pea, 1985; Salomon, 1993; Lajoie & Azevedo, 2000), this study grounds on Jonassen's definition of cognitive tools (Jonassen et al., 1998). While the tool functions as an intellectual partner for students, students use the cognitive tool as a designer while building their understanding in a constructivist learning environment. Jonassen (2000) underlined that the use of cognitive tools had created a new approach to learning and instruction. While the intellectual authority of teachers decreases, the responsibility of constructing their own meaning is given to the students. Students are expected to articulate their knowledge, reflect considering the personal and societal relevance, and regulate their own learning habits (Jonassen, 2000).

Integration of technology as cognitive tools approach emphasizes student-centered learning environments in which students can solve relevant, realistic problems and develop higher-order cognitive skills (Jonassen & Reeves, 1996; Lajoie & Azevedo, 2000). Jonassen and Reeves (1996) define cognitive tools as "technologies that enhance the cognitive powers of human beings during thinking, problem solving and learning" (p. 693). With the help of the cognitive tools, students are engaged in critical thinking, knowledge representation, and meaning making (Ge, Turk, & Hung., 2019; Jonassen, 1995). The common features of cognitive tools are described as their role in supporting students' decision making, metacognitive processes, organization, evaluation and analysis of information, problem solving and collaboration and communication of ideas in multi-modal formats (Lajoie,& Azevedo, 2000; Hsu, Wang & Runco, 2013; Jonassen & Reeves, 1996; Azevedo, 2005). The integration of technology as cognitive tools is based on constructivist epistemology. So, considering experience and meaning making as significant elements of learning; providing opportunities for learners to represent their knowledge with the help of cognitive tools is critical for constructing their own meaning (Tan, 2019).

Yıldırım (2004) studied students' application of visual design principles into hypermedia by using hypermedia as a cognitive tool. The subject matter was visual design principles and students worked in groups to develop a hypermedia-based instructional material in a constructivist learning environment. The study indicated that the majority of the groups applied the subject matter effectively into their products. Regarding the role of cognitive tools in learning process as a partner, the groups used hypermedia as a cognitive tool to construct their knowledge about the subject matter (Yıldırım, 2004). Similarly, Jonassen (2000) emphasized that learning with technology occurs when technology takes a role in promoting knowledge construction, exploration, learning by doing, learning by conversing, and learning by reflecting. On the other hand, cognitive tools in a constructionist setting become invisible when the students focus on learning with the tool, rather than learning about the tool (Papert, 1991).

Another study focused on the impact of a diagram-based cognitive tool on students' collaborative learning in the context of graduate students regarding the potential of technology to support students' social interaction (Cai & Gu, 2019). Its findings indicated that the tool with conceptual and socio-cognitive support contributed students' understanding intensively and helped them engage in cognitively demanding tasks (Cai & Gu, 2019). In addition, a recent experimental study about the concept maps as cognitive tools intended to look for the effect of text-based online visual cognitive tool and the visual concept map on enhancing pre-service teachers' argumentation skills (Su & Long, 2021). It revealed that text-based cognitive tool leaded to a better performance of participants in argumentation.

Hence, it can be concluded that the previous research highlighted the contribution of integrating cognitive tools to learning.

2.3.5 Use of Cognitive Tools in Mathematics Education

By means of cognitive tools approach, the focus has head to leveraging learners' capabilities and affordances of emerging technologies to learn (Herrington & Parker, 2013; Hwang, Shi & Chu, 2011; Liu, Horton, Toprac & Yuen, 2011; Wang, Hsu, Reeves & Coster, 2014; Zap & Code, 2016). Kitchen and Berk (2016) also emphasized the role of educational technology as a cognitive tool that enhances students' reasoning through problem solving and discourse in reforms in mathematics education. They also underlined the need for research on ICTs that help students to apply mathematics concepts and skills (Kitchen & Berk, 2016).

In mathematics education, there are several types of technology. The commonly used technologies are computer algebra systems (CAS), graphing tools and multiple representation tools (Heid, 1997). CAS technology which includes computing tools that perform most graphical, numerical, and symbolic routines (Heid, 1997) can take a role in students' conceptualization of problem. In a study in which algebra teachers use CAS in their classes, the results indicated that this technology led students to re-evaluate their fundamental assumptions through reformulating, solving, interpreting, and evaluating the problem with the revised assumption (Geiger, Faragher & Goos, 2010). Graphing tools and multiple representation tools are generally used to display the graphs, equations, and value tables of functions dynamically. GeoGebra, which is considered as both a graphing tool and computer algebra system, is one of the most popular and widely used dynamic mathematical software which is free, user-friendly, and multi-platform and provides an interactive area to work on geometry, algebra, calculus and statistics for all levels of education (Hohenwarter & Jones, 2007). The use of GeoGebra helps students to visualize problems and prevent algebraic obstacles (Bu & Schoen, 2012). Considering the role of this tool in students' exploration, re-construction, connection, and explanation of mathematical concepts, GeoGebra is considered as a cognitive tool in mathematics education

(Cheng & Leung, 2015). Use of dynamic tools that allows quick representation and browsing various cases which create possibilities to analyze specific situations, and this allows experimentation and investigation in learning mathematics (Budinski, 2017). Butcher and Edwards (2011) used GeoGebra to explore rigid motions through asking “what if not” questions. These questions lead an exploration that can only be experienced by the means of technology. The use of technology as a cognitive tool helps students test their hypotheses and visualize various cases for their proofs.

Another tool that can be used as a cognitive tool in mathematics education is spreadsheets. Jonassen and his colleagues stated the function of spreadsheets as cognitive tools as follows:

> Spreadsheets are an example of a Mindtool that amplifies and recognizes mental functioning. Building spreadsheet models engages a variety of mental processes that require learners to use existing rules, generate new rules describing relationships, and organize information. The emphasis in a spreadsheet is on identifying relationships and describing those relationships in terms of higher-order rules (generally numerical), so it is probable that if users learn to develop spreadsheets to describe content domains, they will be thinking more deeply. (Jonassen, Howland, Marra, & Crismond, 2008; p.89)

According to cognitive tool concept, the spreadsheets can function as computational reasoning for analyzing data, mathematics comprehension and simulation modelling tools (Jonassen, 2000). Regarding computational reasoning, the spreadsheets were used as a calculator while demonstrating multiplicative relationships in elementary mathematics (Edwards & Bitter, 1989). Considering mathematics comprehension, many studies highlighted the potential of the spreadsheets in algebra learning (Ainley, Billls & Wilson, 2005). While students are transitioning from arithmetic to algebra, the spreadsheets play a supportive role (Bills, Wilson & Ainley, 2005; Dettori, Garuti & Lemut, 2001; Rojano, 1996). A study with 6th grade students found that the use of spreadsheets helped students in the pattern seeking process and transitioning from verbal expression of the pattern to its algebraic expression (Ozdemir Erdogan & Turan, 2014). Regarding simulation modeling, the spreadsheets can function as “direct and effective means of understanding the role of various parameters and of testing different means of optimizing their values” (Sundheim, 1992; p. 654.) For instance, Silva (1998) used spreadsheets to indicate various experiments on Archimedes’s law and potential energy.

In many education and technology studies, computer programming instruction is considered as a “paradigm shift” in technological education since it makes students think about the problems differently through various analytic and representational tools (Kochmann, 1996; Papert, 1980). Considering the paradigm shift that programming creates, Pérez (2018) underlined the potential of computational thinking in K12 students’ understanding the use of mathematics rather than thinking mathematics “as rule-bound, linear, and solitary that involves memorized step-by-step procedures in which success consists of arriving quickly at a single correct answer” (Kloosterman, 2002; Lerch, 2004; Schoenfeld, 1989; Thompson, 1992 as cited in Perez, 2018, p. 424). The significance of computational thinking roots in its emphasis on thinking and gaining awareness of the way of computer science practices’ support on successful interdisciplinary problem solving (Hemmendinger, 2010; Wing, 2008). Many researchers mentioned the role of computational thinking in helping students comprehend mathematical concepts as outward oriented (Brennan & Resnick, 2012; Grover & Pea, 2013; Weintrop, 2016). An earlier work with 4th grade students using Logo to learn fractions through programming indicated that students had constructed mathematical representations during the design process of their artifact, and the role of programming as a tool for knowledge reformulation and personal expression (Kafai, 1995). Similarly, another research with 5th grade students in Cartesian Coordinates supports the idea that the learning motivation and achievement could be enhanced through the use of Scratch (Jianzhi, 2011).

Recently, the knowledge of mathematics in Scratch programming activities has been suggested to be considered in designing and organizing students’ learning environments (Grover, Pea, & Cooper, 2015; Han, Bae, & Park, 2016). Scratch is a free graphical programming tool targeting students over 8 years old. It is used to create animations, simulations and games. Su, Huang, Yang, Ding and Hsieh (2015) underlined the easiness of its use and its “opportunities to create increasingly complex projects over time” (p.332). Moreover, there are studies indicating Scratch’s positive effects on mathematics performance and motivation with respect to the performance and motivation in traditional approach (Jianzhi, 2011), and its contribution to the use of problem-solving strategies such as goal setting, generating and testing ideas, and its opportunities to work collaboratively (Taylor, Harlow, & Forret, 2010). So, programming tools can be used in mathematics learning, especially in overcoming students’ mathematics misconceptions, as a cognitive tool to support students’ deeper cognition. Based on the lack of knowledge and skills of elementary mathematics teachers in the use of technology as cognitive tools, the content of the professional development program in this study included the use of Scratch as a cognitive tool in mathematics teaching.

Regarding the discussed roles of some cognitive tools such as Excel and Scratch, it can be seen that they allow students for representation of their understanding with a constructionist approach. The new representations with the help of technological tools in mathematics were studied by many studies (Ainsworth et al., 1997; Borba & Villarreal, 2006; Edwards, 1998; Falcade et al., 2007; Morgan et al., 2009; Noss & Hoyles, 1996; Yerushalmy, 2005). Hence, studies revealed that for mathematics education, the ability to connect various semiotic systems so that changes made to one system cause matching changes to occur in another, such as algebraic equations and Cartesian graphs, and the ability to represent relationships with a dynamic element that can be manipulated by students enabled conceptualizing mathematics in new forms (Morgan & Kynigos, 2014). Hence, including cognitive tools in mathematics classes can create an opportunity for students to understand mathematical concepts better, in turn, along with student achievement, technological competence stated in the curriculum can be achieved through the effective integration of cognitive tools in mathematics.

2.4 Summary of the Related Literature

Considering Turkish students' poor performance in mathematics in both national and international examinations, the role of designing effective mathematics learning settings is underlined as a problem in mathematics education. Also, studies indicated that integrating technology into mathematics lessons contributes students' learning in mathematics when the environment allows students to take active roles and work collaboratively. Moreover, the recent mathematics curriculum supported the student-centered learning activities and ICT's role in learning. In this regard, "Learning with technology" approach with constructivist roots is suitable with the aim of gaining students technological competence stated in the recent mathematics curriculum. With this approach, students are provided chances for constructing their own meaning by using the cognitive tools. This approach emphasizes student-centered learning environments in which students can solve relevant, realistic problems and develop higher-order cognitive skills (Jonassen & Reeves, 1996). In addition, the use of cognitive tools in a constructive framework provide students a variety of critical, creative, and complex thinking opportunities, and an opportunity for students to understand mathematical concepts better. Hence, the integration of cognitive tools can be a promising way for improving mathematics learning. However, the studies indicated that teachers under-utilized technology in their practices and did not possess necessary knowledge and skills for ICT integration and positioning technology as a learning partner in students' learning process. In order to integrate technology as a learning-with medium, teachers need to be involved in effective professional development programs.

Combining the potential contribution of integrating cognitive tools in mathematics learning and the need of professional development activities in technology integration, this study focused on a professional development program through an online CoP. While teacher professional development programs have long positioned teachers as passive consumers of well-prepared knowledge, the importance of collaborating, exchanging material, sharing experiences about teaching in teacher professional development have been highlighted by many studies. Furthermore, teachers' understanding of how to position technology and how to align technology with specific mathematics learning objectives have been emphasized. Since online CoPs provide an environment for continuous and collaborative learning with a subject focus, this study designed a professional development program through an online CoP. Therefore, this study can contribute to the body of knowledge on technology integration as cognitive tools by identifying the experiences and difficulties of mathematics teachers in the context of an online CoP. In turn, it might provide suggestions to support teachers with online CoPs about technology integration as cognitive tools.

CHAPTER 3

METHODOLOGY

This chapter explains the methodology of the study. After research questions are listed, the research design to answer the questions is justified. The following parts of the methodology are participants, the design of the professional development program, the roles within the online CoP, the procedures of the professional development program, context, data collection instruments, data collection procedure, pilot study, data analysis, overview of the study context, validity and reliability and ethical issues.

3.1 Research Questions

Research questions that guide this study are as follows:

1. What are the opinions of teachers on technology integration in mathematics teaching prior to the implementation of the online CoP?
2. How does online CoP for teacher professional development about the integration of technology as cognitive tools affect elementary mathematics teachers' technology integration as cognitive tools in mathematics teaching?
    2.1. What knowledge construction levels are observed in the online discussions during online CoP?
    2.2. What are the indicators of technology integration as cognitive tools in the lesson plans designed by teachers?
3. What are the opinions of teachers on the impact of participation in online CoP on their technology integration practices as cognitive tools?

3.2 Research Design

Due to the nature of this study's exploration of the impact of an online CoP on teachers' technology integration practices as cognitive tools, a qualitative research approach was chosen for in-depth understanding. Creswell (1998) state that a holistic picture can be obtained through qualitative research by collecting a variety of data from the natural setting. The impact of the program was studied in-depth through teachers' opinions related to technology integration before and after their participation, teachers' knowledge construction levels in their online discussions, and teachers' lesson plans as products of their learning. The data was collected from the natural setting of the professional development program.

For this qualitative study, case study was preferred because the researcher aimed to investigate how an online CoP can serve as an environment for teacher professional development on integrating cognitive tools. The unit of study was this online CoP. In order to decide whether the study has the characteristics of "the case study", the conditions for designing a case study proposed by Yin (2003) are examined. Accordingly, to apply case study as a research method, research questions should contain "what", "how" and "why" questions; the researcher should have little control or no control over related behavioral event; and the focus of a study should be based on a contemporary phenomenon rather than historical one (Yin, 2003). In this study, the research questions included "what" and "how" type of questions to examine elementary mathematics teachers' integration of cognitive tools in the context of an online CoP as a professional development program. The nature of "What" and "How" questions in this study indicated that this is an exploratory study (Yin, 2003) regarding the purpose of understanding the impact of online CoP on teachers' technology integration practices as cognitive tools. The researcher did not manipulate or control the learning environment systematically to affect the participation of teachers. The online CoP was implemented based on its design, and the researcher took the facilitator role by sharing and monitoring the activities within the online CoP. Moreover, regarding the other criteria that the study should be focused on a contemporary phenomenon, this study concentrated on the role of an online CoP on teachers' professional development about integrating cognitive tools taking Jonassen's Designing Constructivist Learning Environments Model (1999) as a basis. Although the role of cognitive tools is emphasized in improving students' understanding and higher-order cognitive skills (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur & Sendurur, 2012; Ward &Parr, 2010), there is a need of in-service professional development programs to transform a computer-based tool into a cognitive tool (Akyol & Sendurur, 2019). Based on this need, this study aimed to provide a deeper understanding of how this online CoP as a contemporary way contributed their professional development on a contemporary phenomenon, by employing an exploratory single case study.

The unit of study consisted of a single case, which is this teacher professional development program through online CoP. In this context, online CoP allowed to create teacher networks without location limitations and work on Designing CLE Model (Jonassen, 1999) collaboratively. Hence, the participants from different schools constituted a case within this online CoP. Participants involved in the study from different schools of an education organization. They all volunteered to participate in the program to learn about how to integrate cognitive tools in their mathematics classes and were all following the national mathematics curriculum for grade 6, in which the online CoP focused on its activities. Moreover, the online CoP was implemented during Covid-19 pandemic. Within this context, all teachers maintained their teaching activities in remote learning environments. The detailed information can be found in 3.7. Context section.

During the implementation of the program, they collaborated on a new approach related to technology integration. They studied Designing Constructivist Learning Model (Jonassen, 1999) through watching a video about the model, examining two sample lesson plans, co-constructing lesson plans based on the model, experiencing the lesson plans in their classrooms, and discussing their experiences. While designing their lesson plans, through small group activities, they agreed on an objective that the cognitive tool can help students' understanding regarding the topics they covered in the curriculum, constructed a lesson plan integrating the specified cognitive tool collaboratively, implemented the same lesson plans in their classes, and shared their experiences with each other. Within the large group activity, they discussed each group's lesson plans and broadened their perspective related to integration of cognitive tools in mathematics, which is the purpose of the program. So, within the scope of this online CoP, their professional development was examined in-depth. In conclusion, it can be said that the single case study design is appropriate research method for this study which aims to gain holistic and in-depth information from the natural setting of an online CoP for integrating cognitive tools in mathematics lessons.

3.3 Participants

The participants of the study consisted of 30 elementary mathematics teachers who teaches 6^{th} grades and 30 ICT teachers from different private schools of an education organization in Turkey. 6 elementary mathematics teachers and 6 ICT teachers left the study because of several reasons such as excessive workload caused by Covid-19 and health issues. Hence, 24 elementary mathematics teachers and 24 ICT teachers took part in the study. The schools of the organization were selected due to researcher's convenient accessibility to the selected sample since the researcher works at the organization. Participants volunteered to take part in the study. In order to choose the participants, the following criteria will be applied:

(1) Teachers should have 6^{th} grade mathematics classes in middle school.
(2) There should be no two teachers from the same school.

As the second year of middle school, there is no national exam pressure on both teachers and students and the change in their teaching practices in 6^{th} grade curriculum can be adapted to both lower grades and higher grades. The assignment of elementary mathematics teachers to middle schools in Turkey are based on the departments they graduated. A teacher can work as an elementary mathematics teacher in middle schools if s/he is graduated from the departments of elementary mathematics education, secondary mathematics education and mathematics with a pedagogy certificate. Since the study focuses on online collaboration of teachers for their professional development, teachers from different schools will be selected to minimize face-to-face interaction. During the implementation of the study, education at K12 levels had maintained through remote education because of Covid-19 pandemic. After teachers coped with the first emergency remote education period in the spring semester of 2019-2020 academic year, they had experience in teaching online and they were motivated to learn new tools, techniques, and strategies to integrate technology effectively. Hence, the topic of the study as integrating technology as cognitive tools motivated them to participate. The researcher announced the study and the criteria for participation through school principals and the teachers applied voluntarily.

The study focused on elementary mathematics teachers' use of technology as cognitive tools so the role of ICT teachers in the study was to support teachers' learning about how to use the related cognitive tools, evaluate students' readiness about the cognitive tools, plan necessary trainings of the related cognitive tools for students before the implementation of the lesson plans, and provide technical support during the implementation. Jonassen (2000) mentioned the teachers' technology skills as a challenge while integrating cognitive tools in their classes and suggested that teachers should know the use of cognitive tool well enough to conceptualize its functions and facilitate his/her lesson by modelling, coaching, and scaffolding. Moreover, the social/contextual support element in the model of designing constructivist learning environments was emphasized for the success of implementation (Jonassen, 1999). The teachers that support the learning and the students that learn within constructivist learning environments should be trained according to Jonassen (1999). Hence, the study applied Jonassen's social/contextual support element in his model for determining the role of ICT teachers within the online CoP.

As Table 3.3.1 indicates the demographics of the elementary mathematics teachers, the age of the participants ranged between 28 and 41 while the years of experience ranged between 1 to 18. 13 of them graduated from Mathematics department and took pedagogy certificate, 5 of them graduated from Elementary Mathematics Education and 6 of them graduated from Mathematics Education. 23 of elementary mathematics teachers were female and 1 of them was male. They worked at 20 different cities in Turkey.

Table 3.3.1 Demographics of the participants

Title	**Gender**	**Age**	**Years of Experience**	**BA Degree**
Mathematics Teacher	Female	41	18	Elementary Mathematics Education
Head of Math. Dept.	Female	32	3	Mathematics Education
Mathematics Teacher	Female	37	14	Elementary Mathematics Education
Mathematics Teacher	Female	37	14	Mathematics
Mathematics Teacher	Female	30	8	Elementary Mathematics Education
Mathematics Teacher	Female	36	2	Mathematics
Mathematics Teacher	Female	41	8	Elementary Mathematics Education
Mathematics Teacher	Male	28	6	Mathematics
Head of Math. Dept.	Female	39	16	Mathematics
Mathematics Teacher	Female	30	7	Mathematics
Mathematics Teacher	Female	30	8	Mathematics Education
Mathematics Teacher	Female	28	5	Mathematics Education
Mathematics Teacher	Female	39	16	Mathematics
Mathematics Teacher	Female	33	10	Mathematics
Mathematics Teacher	Female	28	4	Mathematics
Mathematics Teacher	Female	40	16	Mathematics
Mathematics Teacher	Female	37	13	Mathematics
Mathematics Teacher	Female	33	10	Mathematics Education
Mathematics Teacher	Female	33	10	Elementary Mathematics Education
Mathematics Teacher	Female	40	15	Mathematics Education
Mathematics Teacher	Female	31	4	Mathematics Education

Table 3.3.1 (Continued)

Mathematics Teacher	Female	29	1	Mathematics
Mathematics Teacher	Female	42	15	Mathematics
Mathematics Teacher	Female	32	3	Mathematics

3.4 The Design of the Professional Development Program

The aim of this professional development program is to increase teachers' capacity to use technological tools as cognitive tools in middle schools. This professional development program was designed based on two main needs. First one is related to integration of technology into their classroom practices with constructivist approaches. Second one is based on the integration of technology as a cognitive tool in understanding mathematics concepts and eliminating misconceptions for effective mathematics education.

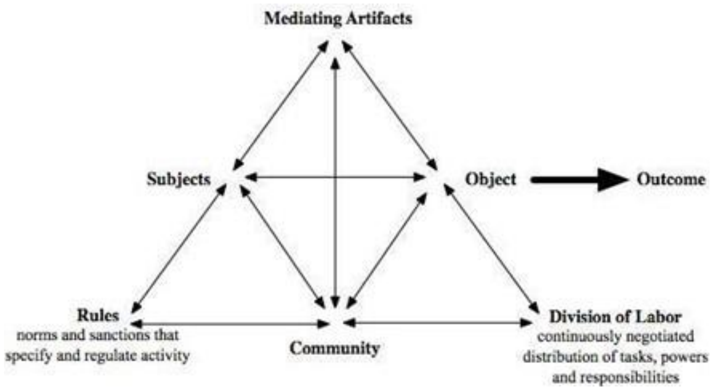


Figure 3 The components of Engöstrom's cultural historical activity theory

The professional development program was designed based on Engeström's activity theory which examines the activity in terms of subject, community, rules, division of labour, mediating tools, object and outcome (2001) (Figure 3.4.).

- **The subjects** were the individuals, elementary mathematics teachers in this study.

- **The community** consisted of the elementary mathematics teachers, ICT teachers, teachers in the private schools of the same organization who works in similar conditions, gets similar educational support such as learning materials, books, seminars and workshops and Ministry of National Education who determines the mathematics curriculum and ICT integration approach in education.

  Most of the schools of this organization were established with a franchising agreement (20 schools). Some of the schools were established with a school foundation (4 schools). All schools have to follow the procedures of the organization related to education. The headquarters of the organization has a department of Schools Management. The department supports the schools by maintaining the recruitment of education personnel, providing procedures and frameworks for educational activities, planning and implementing professional development programs, measuring the success within all the schools and providing school improvement plans. Elementary mathematics teachers have a consultant at the headquarters, supporting them through instructional materials and giving feedback after lesson observations.
- **The outcome of this online CoP** was elementary mathematics teachers' integration of technology as cognitive tools.
- **The objects of this online CoP** were elementary mathematics teachers' learning how to integrate technology as cognitive tools by supporting students' thinking in a constructivist learning environment and how to support students' understanding of mathematical concepts and eliminate the students' misconceptions with the help of cognitive tools.
- In this online CoP, **the rules** were determined as follows:
  (1) Each participant contributes to the creation and maintenance of a supportive open environment.
  (2) Participation in discussions and other learning activities and meeting the deadlines are critical.

- The participation is based on the assigned role in all small group activities and some of the large group activities (The activity of examining sample lesson plans and the activity of sharing the designed lesson plans and evaluating them)
- The minimum participation limits are stated in each activity.

(3) Ethics will be in consideration.

(4) The content will be based on the MoNE curriculum.

- **The mediating artifacts** were listed as follows:
  - Excel and Scratch as the cognitive tools,
  - The social learning platform to interact, share and collaborate,
  - Two sample lesson plans which integrates cognitive tools in mathematics lessons, one is using Excel as a cognitive tool and the other one is using Scratch.
  - Video conference tool for learning the basics of Scratch from ICT teachers and synchronous sessions for small group meetings.
- Considering **the division of labor** component, there were different roles during the discussions, tasks and collaborative design process of lesson plans that is explained in detail in the following section.

3.5 The Roles within Online CoP

Online CoP administrative tasks like sharing the learning tasks, forming the study groups etc. was done by the researcher. The role of the researcher was a facilitator role. In some activities, the whole group were divided into sub-groups to work on designing different lesson plans by choosing an appropriate objective according to the curriculum. Since grouping participants does not lead to improved understanding and performance while constructing knowledge collaboratively (Karakostas & Demetriadis, 2011; Weinberger, Reiserer, Ertl, Fischer & Mandl, 2005), to create a collaborative environment, role assignment methods are frequently suggested (De Wever, Van Keer, Schellens, & Valcke, 2009; De Wever, Keer, Schellens, & Valcke, 2010; Strijbos & Weinberger, 2010). Studies suggested to provide well-defined, clear roles for improving interaction (Bassett, 2011; De Noyelles, Zydney, &Chen, 2014; Gerbic, 2010). Roles are stated as tasks or responsibilities aiming to organize interaction and guide the participants' behaviors within the group (Strijbos & Weinberger, 2010). There are various assigned roles in the literature. For instance, De Wever, Van Keer, Schellens and Valcke (2009) studied five roles; starter, moderator, theoretician, source searcher and summarizer. While the role of starter is responsible for getting discussion started and share new perspectives to enhance discussion; the role of moderator is responsible for providing relevant prompts/questions and monitoring the discussion closely. The role of theoretician is responsible for linking the appropriate theories with the discussion. The source searcher provides extra materials about the discussion topic. The summarizer is responsible for summarizing and concluding the discussed points. The roles of summarizer, source searcher and theoretician are based on cognitive engagement (De Wever et al., 2010). On the other hand, there are also roles based on managing task activities such as project planner, communicator, editor, data collector (Strijbos et al., 2004, 2007). In this study, the roles were chosen to manage task activities based on the literature.

Table 3.5.1 The Design of the Role Structure in Small Group Activities

Roles	Descriptions
Starter/Leader	Analyze the task first and share his/her point of view
	Add new points to be discussed
Facilitator	Monitor the posts closely
	Pose critical questions to elaborate ideas
Timer	Coordinate and moderate the speed of discussion
	Monitor the steps required for the task
Reporter	Construct the product report
	Report the group's ideas/products to large group

In small group activities, the roles and their descriptions are explained in Table 3.5.1. The roles are adapted from the previous examples in the literature (De Wever et al., 2010; Strijbos et al., 2004, 2007; Gu, Shao, Guo, & Lim, 2015; Hancock & Rowland, 2017) and the specific tasks in the professional development program aiming to integration of technology as cognitive tools. In large group activities, the reporter role of each group shares the lesson plan designed by his/her group at the main discussion space.

3.6 Procedures of the Professional Development Program

During the 2020-2021 academic year, the mathematics and ICT teachers participated in the professional development program based on integrating technology as cognitive tools in mathematics classes through an online community of practice. There were large group activities and small group activities within the four parts of professional development program (Figure 4).

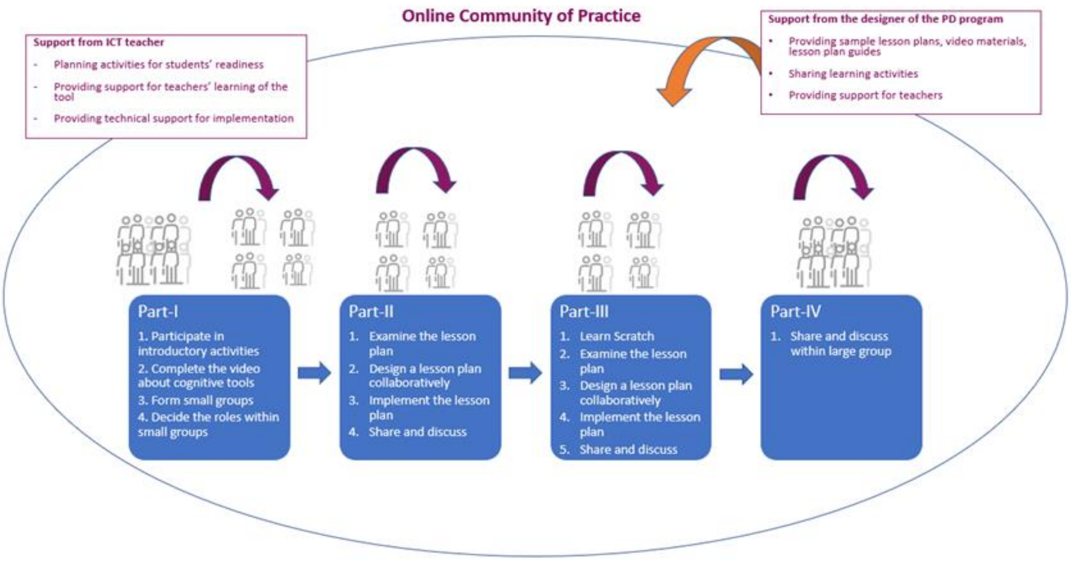


Figure 4 Procedures of the professional development program

Part-I (Both large group and small group activities)

In the first activity, the facilitator introduced the program objectives and the rules for participation in online CoP, and shared a welcoming e-mail including the introduction activity, the schedule of professional development program and the document indicating how to use social groups on the platform. In the introduction activity, participants were asked to share the following information about themselves through a web-based tool, Padlet (Figure 5):

- Names, the school they are working at, the number of years as a teacher
- How they define mathematics and technology in their lives
- Their most favorite technological tool they used in classes
- Their most favorite app they used in their daily lives

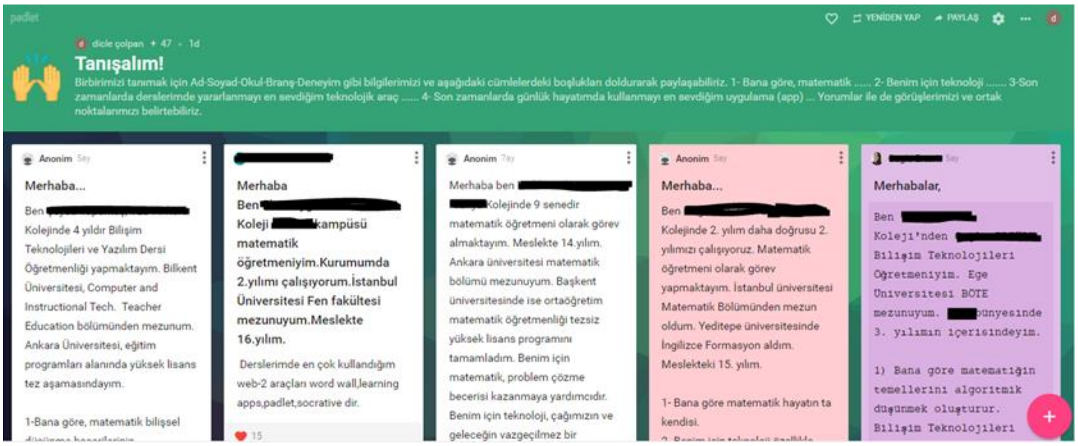


Figure 5 A sample screenshot from the introduction activity

In the second activity, they were given brief information about what the cognitive tools mean and Jonassen's Designing Constructivist Learning Environments Model (1999) by a video recorded by the facilitator. They watched the video within two days on the learning management system.

As a third activity, they were divided into small groups and shared the document including information about the roles within online CoP. Each small group was asked to determine who would be responsible of the given roles for the online CoP activities and decide whether there would be a need for defining another role for maintaining the activities.

Part-II (Small group activities)

In this part, activities were based on examining the sample lesson plan of Excel as a cognitive tool within their small groups, designing a lesson plan collaboratively including Excel as a cognitive tool, implementing the lesson plan in classes, sharing, and discussing after the implementation.

In the first activity, mathematics teachers were asked to examine the sample lesson plan and share their opinions related to the given questions about

- the use of Jonassen's Constructivist Learning Environments Model in the lesson plan,
- what they find effective in the lesson plan and why,
- what they may change if they plan the same lesson and why,
- what other topics in the 6^{th} grade can be appropriate for the use of Excel as a cognitive tool,
- considering other participants' opinions, whether there are parts that they agree or disagree and why.

Meanwhile, ICT teachers were asked to examine the sample plan and share their opinions related to how they can contribute to the learning process.

In the second activity, mathematics teachers were asked to choose a common objective from 6^{th} grade mathematics curriculum that they would like to design a lesson plan including Excel as a cognitive tool and were asked to design their lesson plan based on the given guidelines within their small groups. The objective they work on, and the details of the lesson plan were discussed through both synchronous and asynchronous discussions. The objectives were chosen based on the topics that students cannot understand easily, they have already covered recently, and they can easily relate with the cognitive tool. ICT teachers took a role in evaluation of students' readiness to use the cognitive tool in the lesson plan. The lesson plans were designed based on Jonassen's guidelines (1999) for designing constructivist learning environments. The guidelines are as follows:

1- Select an appropriate problem for the learning focus on
2- Provide related cases or worked examples to enable case-based reasoning and enhance cognitive flexibility
3- Provide learner-selectable information just-in time
4- Provide cognitive tools that scaffold required skills
5- Provide conversation and collaboration tools
6- Provide social/contextual support for the learning environment

They used learning management system's collaborative work area and shared their opinions. The ICT teachers took part in informing mathematics teachers about students' readiness about Excel and planning necessary pre-trainings before the implementation.

In the third activity, they implemented the lesson plan in their classes. They collaborated with the ICT teacher in their school and determined the pre-training sessions in ICT classes to recall students' knowledge and skills about Excel. Moreover, they determined the schedule of the implementation, and the ICT teacher also attended the implementation to provide necessary technical support for the mathematics teacher and the students.

In the fourth activity, each participant shared his/her opinions after the implementation of the lesson plan based on the given questions. Mathematics teachers were asked the following questions:

- During the implementation of the lesson plan, what were the positive features you observed? Why?
- If you were asked to implement this lesson plan to the same group again, what changes would you make? Why?

ICT teachers were asked the following questions:

- Before the implementation of the lesson plan, what did you do for the readiness of the students about Excel?

- As an ICT teacher, what did you observe in the implementation about the use of Excel as a partner in the learning process in mathematics classes?

Part-III (Both large group and small group activities)

In this part, activities were based on participating in Scratch webinar and the follow-up activities, examining the sample lesson plan of Scratch as a cognitive tool within their small groups, designing a lesson plan collaboratively including Scratch as a cognitive tool, implementing the lesson plan in classes, sharing, and discussing after the implementation.

In the first activity, an ICT teacher organized a webinar related to the basics of the Scratch tool collaborating with the facilitator to all mathematics teachers in November 2020. The webinar was recorded and shared with the participants. Some of the participants watched the recording of the webinar. After the webinar, mathematics teachers were asked to construct a Scratch project based on given guidelines. They also worked together with the ICT teacher in their school to learn more about Scratch. They sent their project to the ICT teacher and got feedback about their first project. As a second Scratch learning project, mathematics teachers were asked to construct the Scratch project within the sample lesson plan by themselves. The necessary support and feedback were given by their ICT teacher in their schools.

In the second activity, mathematics teachers were asked to examine a student paper including a common misconception and a sample lesson plan, and share their opinions related to the given questions about:

- the use of Jonassen's Constructivist Learning Environments Model in the lesson plan,
- what they find effective in the lesson plan and why,
- what they may change if they plan the same lesson and why,
- what other topics in the 6^{th} grade can be appropriate for the use of Scratch as a cognitive tool and how Scratch can contribute students' understanding in that topic,

- considering other participants' opinions, whether there are parts that they agree or disagree and why.

Meanwhile, ICT teachers were asked to examine the sample plan and share their opinions related to how they can contribute to the learning process.

In the third activity, mathematics teachers were asked to choose a common objective from 6th grade mathematics curriculum that they would like to design a lesson plan including Scratch as a cognitive tool and were asked to design their lesson plan based on the given guidelines within their small groups. The objective they work on, and the details of the lesson plan were discussed through both synchronous and asynchronous discussions. The objectives were chosen based on the topics that students cannot understand easily, they have already covered recently, and they can easily relate with the cognitive tool. ICT teachers took a role in evaluation of students' readiness to use the cognitive tool in the lesson plan. The lesson plans were designed based on Jonassen's guidelines (1999) for designing constructivist learning environments. They used learning management system's collaborative work area and shared their opinions. The ICT teachers took part in informing mathematics teachers about students' readiness about Scratch and planning necessary pre-trainings before the implementation.

In the fourth activity, they implemented the lesson plan in their classes. They collaborated with the ICT teacher in their school and determined the pre-training sessions in ICT classes to recall students' knowledge and skills about Scratch. Moreover, they determined the schedule of the implementation, and the ICT teacher also attended the implementation to provide necessary technical support for the mathematics teacher and the students.

In the fifth activity, each participant shared his/her opinions after the implementation of the lesson plan based on the given questions. Mathematics teachers were asked the following questions:

- During the implementation of the lesson plan, what were the positive features you observed? Why?

- If you were asked to implement this lesson plan to the same group again, what changes would you make? Why?

- Considering the other participants' comments, are there any parts that you agree or disagree? Why?

ICT teachers were asked the following questions:

- Before the implementation of the lesson plan, what did you do for the readiness of the students about Scratch?
- As an ICT teacher, what did you observe in the implementation about the use of Scratch as a partner in the learning process in mathematics classes?
- Considering the other participants' comments, are there any parts that you agree or disagree? Why?

Part-IV (Large group activity)

In this part, an online large group meeting was utilized for sharing and discussing the two lesson plans of each group designed and implemented. Each group prepared a different lesson plan based on the objective they choose. Each reporter in small groups shared their lesson plans including Excel and Scratch, summarized their small group discussions after the implementation. After the meeting, each participant was asked to comment on at least two lesson plans by evaluating them based on the given questions. For the questions asked by any participant, the designers of that lesson plan were responsible to answer and clarify. Any of the group members could answer the questions.

Mathematics teachers were asked the following questions:

- What can be said about the use of Jonassens's principles of designing constructivist learning environments in the lesson plan?
- What features of the lesson plan would be effective? Why?
- If you were supposed to plan this lesson, what would be different? Why?

ICT teachers were asked the following questions:

- As an ICT teacher, what did you observe in the implementation about the use of Excel/Scratch as a partner in the learning process in mathematics classes?

3.7 Context

The participants were elementary mathematics and ICT teachers from different private schools of an education organization in Turkey. There were one mathematics and one ICT teacher from each school. Schools were at different locations; Afyon, Ankara, Antalya, Aydın, Bursa, Çorum, Diyarbakır, Edirne, Eskişehir, Gaziantep, İstanbul, İzmir, Kayseri, Kocaeli, Mersin, Muğla, Sakarya, Samsun, Şanlıurfa and Zonguldak. The schools are managed through the common procedures of the organization. The recruitment process of education personnel in all schools are maintained through the education organization. The headquarters of the organization supports schools and teachers providing procedures and frameworks for educational activities, planning and implementing professional development programs, measuring and monitoring the success. Elementary mathematics teachers have a consultant at the headquarters. The supportive instructional materials are developed and distributed to all schools by the headquarters. Moreover, the consultant of the elementary mathematics education observes their lessons occasionally, provides feedback for the teachers, and involves in the analysis of needs for the professional development programs.

The focus of this online CoP for teachers' professional development is to create an online learning community in which elementary mathematics teachers construct student-centered lesson plans incorporating cognitive tools collaboratively to make students understand the concepts better and overcome misconceptions, share their lesson plans and evaluate each lesson plan. The headquarters of the schools supported that teachers should have the ability to integrate technology as a cognitive tool for effective mathematics teaching. There was an earlier attempt to improve teachers' knowledge and skills about designing student centered learning environments; however, one-day workshop and a few face-to-face collaborative meetings did not result in a change in their teaching approaches. Continuous collaboration environment for teachers and ongoing support were needed. Moreover, technology integration as a cognitive tool in learning was not studied in the professional development programs of the organizations. Hence, this study provides a chance for continuous collaboration and support mechanism while trying a new approach to the technology integration during the program.

The headquarters provides online professional development programs for teachers such as orientation programs, training programs based on some general topics that the schools need to consider, and training programs based on their branches. There is a learning management system (LMS) to utilize these training programs and teachers are familiar with. In this study, the video training of cognitive tools was shared via this LMS (Figure 6).

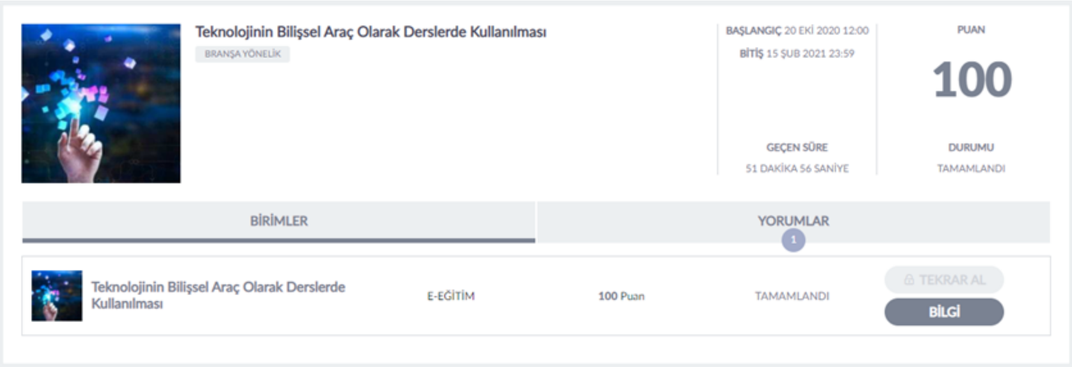


Figure 6 The screenshot of the video training about cognitive tools on the LMS

Moreover, the LMS contains a social learning module. For the learning activities that require asynchronous discussion such as examining lesson plans, sharing and discussing after the implementation, the social learning module was utilized. Each participant joined two social groups, the first one is the main group for large group activities and the second one is the small group. The facilitator shared the learning activity within the related group and teachers replied to this post by answering questions and considering other comments (Figure 7). For the collaborative activities such as designing lesson plans, teachers used the collaborative work area. The lesson plan template was uploaded by the facilitator and teachers shared their ideas in the comments section and added the parts into the lesson plan template. Each small group decided to meet synchronously while designing the lesson plan via Zoom.

They discussed the common objective from the curriculum and shared their ideas for the lesson plan development. After the session, the reporter summarized the discussed topics in the asynchronous discussion area of the small group.

The lesson plans were implemented within the scope of mathematics lessons. In the sixth grade, the mathematics course had 5 hours in a week. ICT lessons were also used for improving students' readiness about the cognitive tools. ICT course had 2 hours in a week. On the other hand, the study was conducted during the emergency remote learning period caused by COVID-19 pandemic in fall and spring semesters of the 2020-2021 academic year. The pandemic started in March, 2020. The 6^{th} grade students had continued remote education for almost the entire year in 2020-2021. Based on the number of cases within their location, some students could go to school for face-to-face education. Hence, the majority of the implementation of the lesson plans occurred in a remote environment. Although teachers gained experience in remote education from the previous year, the duration of the professional development program changed from 6 weeks to 18 weeks (mid-term and semester breaks were excluded) because of their excessive workload caused by remote education, the health issues caused by pandemic and the slow progress in the implementation of mathematics curriculum in remote education. The pre-training activities of the cognitive tools required more time in remote ICT classes. The collaborative studies of the ICT teacher and mathematics teacher within the same school became difficult because teachers were also at different places, and it was difficult to schedule a meeting to work collaboratively. ICT teachers were also responsible for other technical support tasks during the remote education period.

Figure 7 The screenshot of the sample learning activity based on asynchronous discussion on the LMS

3.8 Data Collection Instruments

Based on this qualitative research, the research questions were investigated through interview protocols, online discussion data and the lesson plans that mathematics teachers produced collaboratively. The data sources of the related research questions can be seen in Table 3.8.1.

Table 3.8.1 The Data Sources of the Related Research Questions

Research Questions	**Data Sources**
1. What are the opinions of teachers on technology integration in mathematics teaching prior to the implementation of the online CoP? 2. How does online CoP for TPD about the integration of technology as cognitive tools affect elementary mathematics teachers' technology integration as cognitive tools in mathematics teaching?	Interview data prior to the participation of the online CoP
2.1. What knowledge construction levels are observed in the online discussions during online CoP?	Online discussion data was analyzed based on Interaction Analysis Model (Gunawardena, Lowe & Anderson, 1997)
2.2. What are the indicators of technology integration as cognitive tools in the lesson plans designed by teachers?	The lesson plans were analyzed based on the checklist including indicators of technology integration as cognitive tools
3. What are the opinions of teachers on the impact of participation in online CoP on their technology integration practices as cognitive tools?	Interview data after the participation of the online CoP

Online Discussion Data

The online discussion board within the learning management system was used to collect data of discussion messages. Teachers posted their comments, elaborated their ideas, and provided feedback for their colleagues within the scope of learning activities. The focus of the professional development program was integrating technology as cognitive tools in mathematics classes. There were 4 discussion activities within small groups and 1 discussion activity within the large group based on examining sample lesson plans and sharing and discussing after the implementation. There were open-ended questions in each discussion activity. The discussion activities were self-developed. They were prepared based on the content of the professional development program considering the role of activities in taking participants' own ideas and reflections. The participants were given sample lesson plans including Excel and Scratch as cognitive tools in mathematics. While examining sample lesson plans, mathematics teachers were asked to evaluate the use of Jonassen's Designing CLE Model in the sample lesson plans, what they find effective and why, what they may change if they plan the same lesson and why, and what other topics in the 6^{th} grade can be appropriate for the use of the related cognitive tool. While sharing and discussing after the implementation of the lesson plan they designed, mathematics teachers were asked to reflect on what the positive features they observed during the implementation and what changes they would make if they were asked to implement the same lesson plan to the same group again. The discussion messages were copied from the learning management system and pasted into a document for analysis. The collected discussion data were used to identify the indicators of knowledge construction of teachers in terms of Interaction Analysis Model (Gunawardena, Lowe & Anderson, 1997).

To evaluate the indicators of knowledge construction in online discussions, interaction analysis model (IAM) will be used (Gunawardena, Lowe & Anderson, 1997). The model divides knowledge construction into five phases: Sharing/Comparing, Dissonance, Negotiation/Co-construction, Testing tentative constructions, and Statement/Application of newly constructed knowledge (Table 3.8.2.).

Table 3.8.2 Phase hierarchy and indicators for analysis within each phase of interaction that leads to negotiation of meaning (Gunawardena et al. 1997)

Phase I: Sharing/comparing of information	A. A statement of observation or opinion B. A statement of agreement from one or more other participants C. Corroborating examples provided by one or more participants D. Asking and answering questions to clarify details of statements E. Definition, description, or identification of a problem
Phase II: The discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements	A. Identifying and stating areas of disagreement B. Asking and answering questions to clarify the source and extent of disagreement C. Restating the participant's position, and possibly advancing arguments or considerations in its support by references to the participant's experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view
Phase III: Negotiation of meaning/co-construction of knowledge	A. Negotiation or clarification of the meaning of terms B. Negotiation of the relative weight to be assigned to types of argument C. Identification of areas of agreement or overlap among conflicting concepts D. Proposal and negotiation of new statements embodying compromise, co-construction E. Proposal of integrating or accommodating metaphors or analogies
Phase IV: Testing and modification of proposed synthesis or co-construction	A. Testing the proposed synthesis against ''received fact" as shared by the participants and/or their culture B. Testing against existing cognitive schema C. Testing against personal experience D. Testing against formal data collected E. Testing against contradictory testimony in the literature
Phase V: Agreement statement(s)/application of newly constructed meaning	A. Summarization of agreement(s) B. Applications of new knowledge C. Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the conference interaction

Interview Data

Semi-structured and individual interviews were planned to explore the change in teachers' opinions on technology integration and the impact of participation in the online CoP on their technology integration practices as cognitive tools. There were two interview protocols, the first one was applied before the participation in the professional program and the second one was applied after the participation. Both interview protocols were prepared by the researcher and reviewed by the advisor of this dissertation, who conducted qualitative studies. The first interview protocol as it can be seen in Appendix C included 5 questions to explore teachers' opinions on the use of information and communication technologies in education. The second interview protocol as it can be seen in Appendix C contained 18 questions to explore the change in teachers' opinions on technology integration and the impact of participation in the online CoP on their technology integration practices as cognitive tools. Accordingly, there were 7 questions under the category of the opinions of teachers about the use of ICT in instruction, 11 questions under the category of the opinions of teachers about the instructional design of the online CoP about the integration of technology as cognitive tools. This second interview protocol was conducted after the participation in the professional development program through the online CoP. During conducting interview protocols, the researcher did not follow the exact order and wording, so semi-structured interviews were conducted.

Lesson Plans Designed by Elementary Mathematics Teachers

During the online CoP, teachers collaboratively designed lesson plans in which they integrate technology as cognitive tools. The lesson plans they designed were evaluated based on the quality indicators of the technology integration as cognitive tools constructed by the researcher. In order to measure how elementary mathematics teachers reflect the constructivist aspect of technology integration as cognitive tools after they participate in online CoP aiming technology integration as cognitive tools in mathematics lessons, the lesson plans were analyzed based on the checklist constructed by the researcher (Table 3.8.3). After the checklist was designed, it was examined by the thesis committee and related changes were made based on their suggestions.

The lesson plan attributes are constructed according to Jonassen's Constructivist Learning Environments Model (1999). Regarding the fact that technology can be fully integrated into education only when teachers integrate ICT in order to foster meaningful learning through constructivist approaches (Jonassen et al. 2008; Lee & Hannafin, 2016), this model was used throughout the program. With a similar perspective, cognitive tools were studied to promote meaningful learning in mathematics classes and the lesson plans designed by teachers were evaluated through this model's components and instructional activities.

Table 3.8.3 Lesson plan checklist for evaluating the lesson plans' constructivist aspect of technology integration as cognitive tools based on Jonassen's Constructivist Learning Environments Model

1. Question/Case/Problem/Project	**Yes**	**No**
1.1. Is the lesson plan designed with a focus of a problem that learners attempt to solve or resolve?		
1.2. Is the problem ill-defined or ill-structured?		
1.3. Is the problem authentic that contains tasks replicating the particular activity structures of a context?		
1.4. Is the problem given with its context?		
1.5. Is the problem represented to the learners in an interesting, engaging, and appealing way?		
1.6. Do the activities contain problem manipulation spaces that enable learners to test the effects of their manipulations?		
2. Related Cases	**Yes**	**No**
2.1. Does the lesson plan provide related cases or worked examples to enable case-based reasoning and enhance cognitive flexibility?		
3. Information Sources	**Yes**	**No**
3.1. Does the lesson plan provide learner-selectable information just-in-time?		
3.2. Do the lesson activities include relevant information?		
3.3. Do the lesson activities include accessible information?		
4. Cognitive Tools	**Yes**	**No**
4.1. Do the lesson activities provide learners tasks that require cognitive tools to design and build artefacts?		
4.2. Do the lesson activities provide learners tasks that require cognitive tools to organize and represent what they already know?		

Table 3.8.3. (Continued)

4.3. Do the lesson activities provide learners tasks to negotiate meaning through cognitive tools?		
4.4. Do the lesson activities provide learners cognitive tools to transcend the limitations of their minds, such as limitations to memory, thinking, or problem solving?		
4.5. Do the lesson activities provide learners cognitive tools to scaffold their thinking?		
4.6. Do the lesson activities provide learners tasks to reflect on the activity through cognitive tools?		
5. Conversation/Collaboration Tools	**Yes**	**No**
5.1. Do the lesson activities provide conversation and collaboration tools to support discourse communities, knowledge-building communities, and/or communities of learners?		
6. Social/Contextual Support	**Yes**	**No**
6.1. Do the lesson activities provide social/contextual support for the learning environment?		
7. Instructional Activities	**Yes**	**No**
7.1. Are there activities that require teacher's modeling?		
7.2. Are there activities that require teachers' coaching?		
7.3. Are there activities that require teachers' scaffolding?		

3.9 Data Collection Procedure

After the selection of participants, the demographics data were taken from the database of the education organization in which the researcher works. Technology background of elementary mathematics teachers were collected through an individual interview protocol including 5 questions before the participation in professional development program. The researcher explained the purpose of the study. During the first week of the program, the researcher informed the participants about how to participate in the online CoP, what the collaborative activities were, what the final product they create was. Data collection continued during the professional development program through recording online discussion data. After the participation in the online CoP, the interview protocol including 18 questions was conducted.

3.10 Pilot Study

The pilot study of this research conducted on the spring semester of 2019-2020 academic year. 5 elementary mathematics teachers from Adana, Antalya, İzmir, Karabük and Trabzon and 1 ICT teacher from İstanbul participated in the study. The pilot of the professional development program included the following learning activities:

- introduction activity
- the webinar of cognitive tools
- examining the sample lesson plan integrating Excel as a cognitive tool
- examining the sample lesson plan integrating Scratch as a cognitive tool
- the webinar of block-based programming tool, Scratch
- programming a Scratch project by following the steps in the tutorial
- programming a Scratch project based on the given scenario in the sample plan
- developing a lesson plan integrating Scratch as a cognitive tool
- implementing the lesson plan in the class
- sharing and discussing the observations about the implementation of the lesson plan

Before participation in the online CoP, the elementary mathematics teachers were interviewed through the semi-structured interview questions. They were informed about the learning activities, the features of social groups on the learning management platform (LMS), the duration of the activities, the roles within the online CoP and the rules within the online CoP and all the related information documents were shared on the resources part on the LMS.

All elementary mathematics teachers participated in the introduction activity, the webinar of cognitive tools, the webinar of Scratch, examining the lesson plans, programming the first Scratch project through tutorials, and developing the lesson plans. 40% of the teachers programmed the Scratch project on the sample plan. All of them collaborated on designing a lesson plan integrating Scratch as a cognitive tool. Only one teacher could not implement the lesson plan they developed collaboratively because he fell behind the academic calendar of the curriculum about two weeks. The implementation was planned later with the teacher, however, the schools continued their activities remotely because of the COVID-19 pandemic and the teacher could not implement the lesson plan.

After the learning activities through online CoP, the participants were interviewed. The results and the required changes are stated in Table 3.10.1.

Table 3.10.1 The Changes After the Pilot Study

The ICT teachers in the participants' own schools should participate in the online CoP.	In the pilot study, the participants were 5 elementary mathematics teachers and 1 ICT teacher. They were working at different schools. The ICT teacher guided them through the online CoP. At the end of the pilot study, participants stated that they needed extra help from the ICT teacher in their school, however, they had to explain the content of the training program before they got help. They suggested to include the ICT teacher in their school as a partner for themselves in online CoP. Hence, they can get the help easily and they can work in an interdisciplinary environment.
The readiness of students for the use of cognitive tool should be considered by ICT teachers.	In the pilot study, the students had different prior knowledge and skills about the cognitive tool. Some mathematics teachers could implement the lesson plan easily because their students' readiness was sufficient. On the other hand, some teachers stated that the ICT teachers in the school should have evaluate the readiness before the implementation. If necessary, the cognitive tool should be reminded to the students by ICT teachers.
The learning activities for the use of Scratch should be reconsidered for teachers.	In the pilot study, there was a technical problem about sharing the screen of the trainer during webinar. Hence, after the presentation about algorithm and block-based programming, Scratch, the participants were asked to start their first project by pursuing a tutorial rather than following the steps on synchronous session. They pointed out that they had got help from the ICT teachers in their school to learn Scratch. Hence, the learning activities for Scratch should be redesigned and ICT teachers should be involved.

Table 3.10.1 (Continued)

Different cognitive tools should be examined and highlighted through learning activities.	In the pilot study, two sample lesson plans were examined including Excel and Scratch as cognitive tool and one lesson plan was developed and implemented including Scratch as a cognitive tool. The interviews indicated that participants limited the cognitive tool concept with Scratch. Hence, there should be more examples of other cognitive tools within the cognitive tools' presentation and the cognitive tools should be highlighted in examining sample lesson plans. Moreover, in the actual study the participants developed and implemented two lesson plans including Excel and Scratch.
The participation on discussions should be limited to a time interval at evenings.	In the pilot study, the teachers stated that the roles of timekeeper and leader require too much time to check every participant's activity. The teachers suggested to limit the participation time at evenings so that they can follow others' comments and increase the interaction.
The informative parts should be given by videos instead of synchronous sessions.	In the pilot study, the webinar about cognitive tools session consisted of mostly information about the concept of cognitive tools. The participants suggested to use informative videos rather than synchronous sessions. For the actual study, the webinar of cognitive tools should be changed into a video produced by the researcher.
The learning activities should be reconsidered for giving opportunity to construct knowledge collaboratively.	In the pilot study, the interaction records were analyzed based on Interaction Analysis Model (Gunawardena et al. 1997) and 75% of the comments were grouped under the category of Phase I: Sharing/comparing information. In order to create environments for higher phases for knowledge construction, the learning activities should be reconsidered.

3.11 Data Analysis

Analysis of all data collected through interviews, lesson plans, and online discussions in this qualitative case study was based on content analysis and thematic analysis (Table 3.11.1). As a unit analysis, sentence was selected throughout the analysis procedures.

Regarding first and forth questions, the interview data was conceptualized and organized and then themes related to how they perceive technology integration before their participation and how they perceive the impact of participation in the online professional development program on their technology integration practices. The steps given in Figure 8 were conducted for thematic analysis.

Figure 8 Steps for thematic analysis

Considering second research question, the content analysis procedures were employed to analyze discussion content through Interaction Analysis Model (Gunawardena, Lowe & Anderson, 1997). The model helps to analyze discussion messages in terms of five phases; sharing/comparing, dissonance, negotiation/co-construction, testing and modification and statement/application (Gunawardena, Lowe & Anderson, 1997).

For the third research question, the lesson plans were analyzed based on the checklist designed by researcher for evaluating the lesson plans' constructivist aspect of technology integration as cognitive tools. To evaluate the lesson plans based on this checklist, the criteria for each question was identified based on the related literature of constructivist learning environments and cognitive tools as it can be seen in Appendix D. The lesson plans were searched for the relevant parts indicating the criteria of the related questions. A sample analysis of the lesson plans with the identified criteria was shown in the Appendix E.

Table 3.11.1 Data analysis techniques used in the research

Data sources	**Data analysis techniques**	**Research Questions**
Interview data	Thematic analysis	What are the opinions of teachers on technology integration in mathematics teaching prior to the implementation of the online CoP?
Online discussion data	Content analysis based on Interaction Analysis Model (Gunawardena, Lowe & Anderson, 1997)	What knowledge construction levels are observed in the online discussions during online CoP?
Lesson plans	Content analysis based on the checklist designed by researcher	What are the indicators of technology integration as cognitive tools in the lesson plans designed by teachers?
Interview data	Thematic analysis	What are the opinions of teachers on the impact of participation in online CoP on their technology integration practices as cognitive tools?

3.12 Validity and Reliability

Guba and Lincoln (1989) consider judging the quality of qualitative research similarly to judging the quality of positivist, quantitative research. Accordingly, credibility, transferability, dependability and confirmability are considered as internal validity, external validity, reliability and objectivity, respectively.

Credibility

The validity is defined as "the correctness or credibility of a description, conclusion, explanation, interpretation, or other sort of account." by Maxwell (1996, p. 87). For credibility, member checking is recommended as a process of verification with respondents about the data collected and analyzed (Mertens, 2015). In this study, the interviews were recorded and transcribed by the researcher. Later, the interviewees were requested to examine interview summaries to ensure that the researcher's interpretations accurately describe their responses regarding credibility of the study.

Moreover, triangulation strategy was used to foster credibility and confirmability of the study. Triangulation requires to use multiple data sources from various individuals, different types of data, and variety methods for data collection (Creswell, 2007). In this study, 24 teachers working in different schools participated. The opinions of teachers related to the technology integration were collected through initial interviews before the implementation of the online CoP. Similarly, their opinions related to the impact of participating in the online CoP on their teaching practices were investigated through interviews after the implementation of the online CoP. During the implementation, teachers' online discussion messages served as data sources to investigate teachers' knowledge construction levels. Moreover, the lesson plans were another data sources indicating teachers' products as a result of their participation in the online CoP.

Transferability

Transferability is considered as the qualitative parallel to external validity (Guba & Lincoln, 1989) which is concerned with generalizability of the findings. Use of convenience sampling requires not to generalize the results of the study beyond the given population pool (Mertens, 2015). In order to strengthen transferability of the results of the case study into similar contexts, the context and participants of the study were explained in detail. Although the findings of case studies are not generalizable, the exploration of a new phenomenon within a limited context provides valuable information to the literature and practice.

Dependability

Dependability is considered as the qualitative parallel to reliability (Guba & Lincoln, 1989), which is concerned with obtaining the same results over time by repeating the data collection procedure. Although qualitative research is based on the context and participants of the study, which leads to the inference that the results cannot be the same with other repetitive studies (Yıldırım & Şimşek, 2011), Yin (2009) suggested creation of case study protocol and development of a case study database in order to ensure reliability. In this study, a case study protocol including detailed description of the research process were created to standardize the investigation. In addition, a case study database was developed by keeping the data collected (online discussion transcripts, interview recordings and transcripts, data analysis documents).

Confirmability

Confirmability is considered as the qualitative parallel to objectivity (Guba & Lincoln, 1989) which is concerned with minimized influence of researcher. In this study, coding check was conducted in qualitative data analysis which is recommended by Lincoln and Guba (1985). In order to ensure confirmability in content analysis of online discussion transcripts and thematic analysis of interview transcripts, inter-coder reliability will be calculated offered by Miles and Huberman (1994) for determining knowledge construction level based on Gunawardena et al.'s (1997) interaction analysis model. %20 of the data was given to another expert to recode. If there are disagreements, they discussed and resolved. Also, both the transcripts and thematic analysis of interviews were cross-checked by the researcher and another expert. In addition, triangulation strategy as mentioned above enhanced the confirmability of the study.

3.13 Ethical Issues

Throughout the study, ethical principles were carefully considered by the researcher. Firstly, the researcher requested an evaluation for the report of conformity to ethical codes of human research studies from the Committee on Human Ethics at Middle East Technical University. The committee was given the research scope, data collection procedures, data collection instruments of the study to get permission and the research permission was obtained to conduct the data collection procedures (Appendix A). Secondly, this study was conducted with the participants who are the elementary mathematics teachers who works different schools of an education organization. The education organization also gave permission to apply research study with the voluntary teachers in the schools associated with the organization. The participation in the research was based on the teachers' consent. Participants were given the informed consent form including the goals of the study and how the collected data is used before the teacher professional development program begins (Appendix B). Moreover, the researcher orally informed the participants about the study and its procedures at the beginning of the study. By the informed consent forms, all the participants acknowledged their voluntary participation. In addition, confidentiality was maintained using unique identification names for all teacher participants throughout reporting. Collected data was stored privately and not shared with others not related to the study. Finally, the researcher was careful in her relationship with the teachers to create friendly relationship and open communication throughout the study.

3.14 Researcher Role and Bias

The researcher had prior experience on teacher professional development. She had been working at the headquarters of the education organization which the schools of all the participants were affiliated with. Her responsibilities comprised of analyzing the training needs, designing, implementing, and evaluating teacher professional development programs. She had also taken a role of supporting teachers' technology integration, particularly in the emergency remote learning period because of Covid-19 pandemic. Hence, it was highly possible that her awareness about the problems in teacher professional development and teachers' integration of technology as well as inherent benefits might have caused in researcher bias influencing her approach during analysis and interpretation phases of the study.

In this study, the researcher designed the learning activities in the online CoP, took a role of moderator during the activities, shared the activities on the learning management system, guided the teachers through the activities, attended Scratch webinar and the groups' synchronous sessions during designing of the lesson plans. Before and after the professional development program, the researcher acted as the interviewer by asking questions to the teachers. She was strictly careful about not asking leading questions to verify her own beliefs and the interview questions were reviewed by three subject field experts. Furthermore, the researcher took advantage of a variety of data sources such as discussion data, the lesson plans which teachers designed as well as interviews, and took reflexive notes during the analysis process. Based on these notes, the researcher evaluated the responses of the participants by realizing her own beliefs and avoiding any interference. In addition, multiple researchers were involved in the analysis of the data to minimize researcher's bias.

CHAPTER 4

RESULTS

In this chapter, the results of the study are presented according to the three main research questions, and two sub-questions. First, the findings that indicate the opinions of teachers on technology integration in mathematics teaching prior to the implementation of online CoP are reported based on the interview data. Second, the findings that show the effects of online CoP for teacher professional development about the integration of technology as cognitive tools on elementary mathematics teachers' technology integration with a constructivist approach are provided. The second question is examined through two sub-questions. Through those sub-questions, the findings related to the knowledge construction levels that are observed in the online discussions during online CoP and the indicators of technology integration as cognitive tools in the lesson plans designed by teachers are explained based on the data of online discussions and lesson plans, respectively. Third, the opinions of teachers on the impact of participation in online CoP on their technology integration practices as cognitive tools are stated based on the data of interviews.

4.1 The Opinions of Teachers on Technology Integration in Mathematics Prior to the Implementation of the Online CoP

This part presents the answer for the first research question: What are the opinions of teachers on technology integration in mathematics teaching prior to implementation of online CoP?

The opinions of the teachers on technology integration in mathematics were collected through interviews before their participation of online CoP about technology integration as cognitive tools. The results are examined under four themes: integration of technology, teachers' opinions towards technology integration, challenges, and teachers' experiences.

4.1.1 Integration of Technology

The technology integration experiences of the teachers were analyzed prior to their participation of online CoP. The results of these analyses have been reported in five themes: facilitating instruction, attention and motivation, assessment, instructional preparation, and administrative purposes. The categories under each theme, the number of participants stated the relevant category, and the frequency of statements are given in Table 4.1.1.

Table 4.1.1 Integration of Technology

Themes	**Categories**	**Number of participants (*n*)**	**Frequency (*f*)**
Facilitating instruction	Instructional delivery	22	74
	Drill and practice	13	33
	Videos	13	29
	Visualization	11	31
	Simulation	8	20
	Collaboration	1	1
Attention and Motivation		21	126
Assessment	Exam and quiz	15	54
	Feedback	4	10
	Homework	4	9
	Student projects	3	7
Instructional preparation		18	47
Administrative purposes		5	6

Total number of participants: 24

4.1.1.1 Facilitating Instruction

According to findings, teachers integrated technology to facilitate their instruction in mathematics classes. The results are grouped into six categories within facilitating instruction: instructional delivery, drill and practice, visualization, videos, simulation, and collaboration.

Instructional delivery

According to the interviews conducted before teachers participated in the online CoP, they shared that they benefited from technology for instructional delivery (*n*=22, *f*=74). While they stated that they used to use presentation programs, smartboards, and the applications of course books in smartboards before the pandemic, they also shared that they maintained their classes with the help of video conferencing tools by using the whiteboard feature during the emergency remote learning period. A sample quote indicating teachers' integration of technology for instructional delivery is as follows:

> "Also, we do more operations in math class. We are solving questions. I share the screen and have a tablet pen. I'm showing them one-on-one. It would be nice if it was a little interactive, with the participation of children. So that's how I use it more." [01]

Similar to the integration of technology before the pandemic, teachers benefited from powerpoint presentations and applications of their course books during the remote emergency learning period as well. One of the teachers explained the use of applications of the course book during instructional delivery by stating the following:

> "I also usually use the smart board with our z-books. Especially in the solutions in the books I have assigned homework, they have functions that not only do not waste time writing the question again, but also bring the question closer in itself. Even if you did the solutions on it, the systems that allowed the children to see only that question were very useful for us. I was using it in this sense." [02]

Drill and practice

Findings indicated that teachers integrated technology into their mathematics lessons for drill and practice (*n*=13, *f*=33) in class activities. They benefited from the applications of their course books for variety of questions, integrated some web 2.0 tools for drill and practice, and organized mathematical games with them. One of the participants shared her experience in this regard as follows:

> "Especially at the end-of-class when energies are low, we do it so that they can solve at least a few questions related to the subject." [03]

During emergency remote learning period, they also benefited from drill and practice activities with the help of web 2.0 tools. A teacher stated her technology integration for drill and practice during this period as follows:

> "After explaining the subject, we sent a link to the children, when we linked the chat section on Zoom, they were directed directly to the game." [04]

Videos

Teachers stated that their technology integration practices included use of videos (*n*=13, *f*=29) in mathematics classes. Accordingly, they integrated videos into their instruction to attract students' attention, relate the topic with daily life, and enhance students' understanding. A sample quote stating the use of videos is as follows:

> "I also benefit from EBA's videos. You know, I covered the subject, for example, for 6 grades, I taught exponential numbers. There is this chessboard story about exponential numbers, for example, at EBA. I had the kids watch it. You know, yes, I continue to use EBA to attract children's attention." [05]

On the other hand, one of the participants shared her experience of flipped class. During the emergency remote learning period, her school benefited from flipped class approach in which students watched the videos of content before synchronous sessions out of class and attended synchronous sessions for solving questions. A sample quote in this regard is as follows:

> "We were using the flipped class more during the quarantine period. Since the number of lessons was few, the children mostly studied on their own. But we will use it this year as well. Students' exams will start in the coming weeks. They will come to schools and have exams. Then they will return home for lectures. This will take a while. In this way, the whole program will delay. The school turned all the synchronous lessons there to asynchronous. Since it makes it asynchronous, we will have to implement a flipped class. They will watch the videos in advance. We will go over the topics in the video and continue to solve the questions." [06]

Visualization

According to the interviews, 11 out of 24 teachers also integrated technology for visualization purposes (*f*=31). Within this category, they mentioned use of visuals and dynamic mathematics softwares to help students understand and concretize mathematical concepts. A sample quote related to the use of visuals to help students understanding is as follows:

> "I find Vitamin very useful, we use it a lot in the introduction to the subject. Because its visualization is good. The child learns more easily when they at least see that visual part among such abstract and concrete ones, and they grasp it faster. When you talk about millions and stuff, the graphics they used at work were pretty good." [07]

One of the teachers also shared that she benefited from a dynamic mathematics software, GeoGebra, to show students how to draw geometrical objects in related topics.

Simulation

Another way of integrating technology into mathematics classes is stated as simulations (*n*=8, *f*=20). Teachers mostly benefited from the simulations in GeoGebra to indicate mathematical relationships by changing variables.

> "Mostly GeoGebra… For example, I just used it, creating different rectangles with the same area, changing the side lengths. So, it is not possible to describe it by drawing. Here I use their simulation to get different rectangles by simply entering a value." [08]

Although their use exemplified a teacher-centered approach in which they show what happens when the variables are changed, they stated that they shared the links of simulations with students to give them chance to experience.

Collaboration

Only one out of 24 teachers mentioned that she took advantage of Zoom's breakout rooms for collaboration (*f*=1) during the emergency remote learning period. Accordingly, she grouped students on the platform and assigned a task in which students collaboratively work on.

4.1.1.2 Attention and Motivation

According to the interviews, teachers integrated technology to attract students' attention towards mathematics lessons and motivate them to learn mathematics (*n*=21, *f*=126). While the activities including technology catch their interest into the subject, involving technology integrated activities in learning process help students motivate towards learning the related subject. One of the teachers stated the role of technology integration in students' motivation to learn by stating the following:

> "When you have fun activities like in Morpa, their learning is a little different because they like it. I can say that they learn faster because they are more willing." [09]

Considering students' bias related mathematics, teachers tried to attract students' attention to the lesson through integrating technology into their lessons by using videos or web 2.0 tools. Since technology increases their interest, it affects the lesson positively. A sample quote in this regard is as follows:

> "Therefore, one of the most important things is motivation and breaking children's prejudices against mathematics. Because it increases their interest." [10]

On the other hand, one of the participants highlighted that while integrating technology to attract students' attention and motivate them, they may have lost the focus of the activity they were doing. For instance, the teacher shared the effect of drill and practice activity with a web 2.0 tool that she used for drawing attention by stating the following:

> "Yes, you attract the attention of the child, yes, at that moment you are dealing with excited and attentive children, but we are a little disconnected from the main purpose of the work, my purpose of teaching. If we're doing Kahoot, they get interested in that music and lose their focus." [11] Assessment

According to findings, teachers integrated technology to assess students' understanding in mathematics classes. The results are grouped into four categories within assessment: exam and quiz, homework, feedback, and students' projects.

Exam and quiz

Teachers stated that they benefit from various applications to assess students' prior knowledge or learning in mathematics classes (*n*=15, *f*=54). One of the teachers shared her way of integrating technology for assessment as follows:

> "Frankly, I mostly use technology with applications to check their prior knowledge after learning the subject or before learning the subject. Like what? For example, I check more preliminary information on tools such as Kahoot, Quizziz, Quizlet, Socrative and sometimes plan my lessons accordingly. Since our course is already mathematics, that is, it is more of a numerical course… Or I use it in the form of a small quiz after I have studied the subject, to give feedback on where the child is, what can I do, how can I guide him." [12]

While most of them integrated technology for exams and quizzes, one of the teachers highlighted that these assessment activities with technology did not indicate the actual results of students' understanding because they were actually used for students' motivation. A sample quote in this regard is as follows:

> "Actually, I don't see it as a very healthy practice in terms of measurement, but I still think it is a good practice in terms of increasing the energy of children." [13]

Feedback

Findings indicated that teachers' in-class technology-integrated assessment activities included feedback for students (*n*=4, *f*=10). One of the participants explained how she used web 2.0 tools to provide feedback instantly during the class by stating the following:

> "In fact, they think they are having fun, but they are learning at the same time. Because we talk to them in every single question. Look, this is how it is, you said, 3 people gave wrong answers, but the reason is because of this, we tell them the question without being noticed." [14]

Homework

As well as exams and quizzes, teachers stated that they benefited from some digital platforms to assign students homework (*n*=4, *f*=9). Through these platforms, teachers curated and sent homework papers which help students drill and practice out of the class and collected homework. A sample quotation in this regard is as follows:

> "We give homework through it. We want them to send them through the platform. We use the results digitally on the platform, such as who could not answer how many questions, what percentage the question had, or which questions we assign more and which we did not." [15]

Students' projects

According to interviews, 3 teachers out of 24 teachers stated that their technology integration practices related to assessment included assigning projects in which students created their artifacts by using a technological tool out of class (*f*=8). In these projects, students researched, organized information, and created products such as preparing a video including where to use mathematics in daily life, a presentation or poster related to the subject with technology including their research studies. One of the participants shared her experience in this regard as follows:

> "For example, the child can do a study using whichever program he or she feels close to, if he is a master. For example, in the moviemaker, the boy said, "I'm going to make a movie." Okay, he's putting the story of zero into it and sending it into a movie. By thinking about things that they can prepare themselves, we also make them use it at that point in the lessons." [16]

4.1.1.3 Instructional Preparation

During the interviews held before teachers' participation in online CoP, teachers stated that they got help from technology while doing their instructional preparation for classes (*n*=18, *f*=47). These activities included preparing presentations, homework, exams, and quizzes. One of the participants shared her technology integration practices for instructional preparation as follows:

> "We are preparing a PowerPoint presentation, especially for video shoots. But we do the lecture from our book. We follow it. Only sometimes, for example, when we prepare small repetitions before exams, presentations work for us. Of course, we use Word to write questions." [17]

4.1.1.4 Administrative Purposes

Teachers also benefited from technology for their administrative tasks such as storing their files, following exam results, and communicating with parents and school management (*n*=5, *f*=6). A sample quote in this regard is as follows:

> "We use Excel mostly for exam results." [18]

4.1.2 Teachers' Opinions Towards Technology Integration

Findings indicated teachers' opinions about technology integration before they participated in the online CoP. The results are reported in seven themes: benefits, willingness, positive opinions, negative opinions, questioning the role of integrating technology, enjoyment, and opinions about cognitive tools. The categories under each theme, the number of participants stated the relevant category, and the frequency of statements are given in Table 4.1.2.

Table 4.1.2 Teachers' Opinions About Technology Integration

Themes	**Categories**	**Number of participants (*n*)**	**Frequency (*f*)**
Benefits	Increasing attention and motivation	21	122
	Increasing efficiency	14	48
	Resources	10	23
	Helping cognitive processes	4	6
	Learning from technology	1	1
Willingness		16	37
Positive opinions		8	20
Negative opinions		7	22
Questioning the role of integrating technology		7	21
Enjoyment		1	5
Opinions about cognitive tools		24	34

Total number of participants: 24

4.1.2.1 Benefits

While mentioning their attitudes towards technology, teachers highlighted the benefits of integrating technology in their classes. These benefits are grouped into five categories: motivation, increasing efficiency, helping cognitive processes, resources, and learning from technology.

Increasing Attention and Motivation

While integrating technology in their classes, teachers emphasized that they benefited from its effect of increasing students' attention and motivation (*n*=21, *f*=122). They integrated technology into their lessons to catch students' interest, help students engage in learning activities, and make them associate technology and mathematics. Regarding the characteristics of this generation students and the importance of technology in their lives, integration of technology was considered as a way of both attracting their attention to mathematics lessons and motivating them. One of the participants explained her opinion in increasing students' motivation by stating the following:

> "Technology is something they already love and are into. That's why it has a huge impact on motivating them." [19]

Another teacher shared how she used a web 2.0 tool to attract students' attention to the subject as follows:

> "I use Padlet at the beginning of the lesson. A little more to focus the children on the lesson and to draw attention…" [20]

Increasing efficiency

Another benefit that teachers emphasized as a benefit while integrating technology is increasing efficiency (n=14, f=48). Regarding efficiency, they shared how assessment applications helped them see students' understanding instantly, provide feedback easily, take notes about each student, and not spend too much time for checking students' exam papers. A sample quote in this regard as follows:

> "For example, when I do a quiz, I instantly see what each child is doing in Classkick, making it easier for me to identify each child. I was able to instantly click on the child I wanted and see how he was writing at that moment. Even in the normal classroom, the exam paper comes before me, but at that moment, I do not know what kind of thought the child made, how he wrote it. Being able to see what each child is doing instantly helped me get better notes for each child, in terms of getting to know the children." [21]

Another benefit related to efficiency was stated as not spending time for writing questions on the whiteboard, not waiting for students to take their own notes, and being able to solve more questions in class time. Teachers prepared their presentations including questions to be solved and sent the lecture notes and presentations to the students. A teacher shared her experience in this issue by stating the following:

> "For example, it took a lot of time to write questions and write problems in mathematics. While we can solve 5-6 questions in a lesson I write on the

> board, say for high-level groups, this way we can solve 10-15 questions." [22]

Using the applications of course books allowed teachers to zoom in and out to indicate questions and show the solutions of questions with one click. Through this method, teachers only explained the solutions, in turn these applications gained them extra time for more questions. During the emergency remote learning period, teachers benefited from the whiteboard feature of video conferencing tools and graphical tablets to write and draw as if using a real whiteboard.

Helping cognitive processes

Considering the benefits of technology integration, teachers stated that it helped students' cognitive processes (*n*=4, *f*=6) while learning mathematics. Accordingly, students can understand abstract topics more easily with the help of technology integration. A sample quote in this regard is as follows:

> "By integrating technology in this way, I think we can make it a little more understandable and a little more fun." [23]

Resources

While doing the instructional preparation, teachers stated that they benefited from various resources (*n*=10, *f*=23) from the internet and curate their own lesson content based on students' needs. These resources included different worksheets, videos, visuals, and questions. A teacher shared how she got help from technology for resources by stating the following:

> "I also embed the video myself, I also put my images, I also put my questions. That way, it's under my control. Rather than printing something out of a book or a text written by someone else, teaching the lesson with the content I prepared according to the potential or dynamics of the class is more beneficial both for me and for my communication with the children." [24]

Learning from technology

Out of 24 teachers, only 1 teacher mentioned that students could take advantage of technology integration by learning how to learn from technology (*f*=1). A sample quote which stating technology integration's supportive role in students' learning from technology is as follows:

> "That is, learning to learn... In this process, teaching children to learn by themselves... I think of it as a tool that supports lifelong learning." [25]

4.1.2.2 Willingness

According to the interviews, 16 teachers stated that they would like to learn more about technology integration (*f*=37). Although they have integrated technology into their classes in many ways during the emergency remote learning period, they stated that they needed more trainings about technology integration. One of the participants shared her opinion indicating her willingness as follows:

> "And most importantly, I aim to learn how to integrate this into mathematics on behalf of our own branch." [26]

4.1.2.3 Positive opinions

Findings indicated that out of 24 teachers, 8 of them had positive opinions (*f*=20) about technology integration in mathematics classes. Accordingly, they suggested that it should be integrated as much as possible to support students' learning. It was considered as an important part of the lesson but the allocated time for integration should be considered not to cause any delays in curriculum. One of the participants emphasized the balance of technology integration in classroom environment by stating the following:

> "When we include it in our teaching, we see its benefit more by balancing it. For balance, it is necessary to consider them all together." [27]

Only one of the teachers mentioned that the technology should be integrated but it should be used by the teacher. A sample quote in this regard is as follows:

> "I don't see any negative aspects when it is used by the teacher, but when we leave it to the children's initiative, when we say okay you can do it, they can use it in a bad way. I don't think it does much harm when it's under the teacher's control." [28]

4.1.2.4 Negative opinions

Some of the teachers shared their negative opinions regarding technology integration before their participation in the online CoP (*n*=7, *f*=22). Accordingly, teachers mentioned three aspects. One is the opinion that the structure of mathematics was not compatible with integrating technology. A teacher stated her belief in this issue as follows:

> "But of course, it is not that broad to progress in mathematics, as it is in many different areas such as verbal lessons, social studies, and Turkish. I can say that we can stay at a certain point." [29]

With a similar point of view, teachers considered that technology leaded students to laziness in which students expect to reach results easily in mathematics whereas mathematics requires patience and discipline.

> "Sometimes there are points where it pushes the student into laziness. For example, when you click on the notebook I use, the answer will open. You know, there are points that push a little more laziness. Let's see without any effort. At this point, it pushes the student to laziness at some points. It prevents the student from doing anything. It interferes with the thinking process because, for example, I can open the answer with one click from there. So, open it right away, let's see the answer, let's move on to the next question." [30]

Another aspect is that teachers suggested students to avoid use of technology out of school before the pandemic. One of the participants considered the reason of this suggestion by stating the following:

> "We think it has negative effects for students because we haven't been able to teach it to use it properly yet in general. Not only at school, but also outside… This is what I observed from students." [31]

4.1.2.5 Questioning the role of integrating technology

Considering teachers' opinions towards technology integration, they shared their questioning the role of integrating technology (*n*=7, *f*=21) before their participation in the online CoP. Accordingly, they stated that technology should not be integrated by placing it as a goal. However, the pandemic and emergency remote learning period affected their integration practices. One of the teachers shared her opinion in this regard as follows:

> "In other words, we think about which feature we should use in our lesson rather than what activity we should do." [32]

Furthermore, teachers stated that they would like to learn how to integrate technology by placing it as a learning tool, giving students chance to experience and discover mathematical relationships. A teacher shared her opinions in this regard by emphasizing the teachers' role as follows:

> "But how do we achieve that integration here? Frankly, I don't want the teacher to be in the position of using it all the time. At least the child should be able to go to a laboratory. Everyone should be able to do something at the computer so that I can see their feedback and evaluation in the measuring section." [33]

4.1.2.6. Enjoyment

Out of 24 teachers, 1 of the participants mentioned that technology integration practices provided enjoyment (*f*=5) for herself because it gave chance to change the traditional method in her classroom. She participated in technology committee in her school and implemented technology integration practices in her class. With every implementation, she felt enjoyment because she could apply technology by changing her prejudices. She shared her experience by stating the following:

> "It also increased my knowledge. This affected me positively and motivated me professionally." [34]

4.1.2.7. Opinions about cognitive tools

During the interviews conducted before the implementation of online CoP, teachers were asked about what the integration of technology as cognitive tools means to them. They shared opinions towards cognitive tools (*n*=24, *f*=34).

Out of 24 teachers, 10 teachers emphasized that they would like to learn how to plan a mathematics lesson by integrating different tools although they had no idea about the cognitive tools. Ten teachers shared that they considered technology integration as cognitive tools as positioning technological tools to help students' cognitive processes during learning. One of the participants shared her opinion in this regard as follows:

> "On the one hand, children will do math with fun, but technology should also contribute to their cognitive development. In fact, the child will have to think about the solution while thinking about what to do, especially while learning to code. This is the part of this training that really excites me." [35]

As it was stated in the previous quotation, some teachers thought that cognitive tools help them motivate students and attract their attention (*n*=7) and increase efficiency in class (*n*=2). There were also teachers who associated cognitive tools with placing students as users of technology while learning (*n*=3) and learning from technology (*n*=1). Only one of them considered that technology integration as cognitive tools was related with teaching mathematics remotely.

4.1.3 Challenges

Findings indicated challenges that teachers encountered during technology integration. The results are reported in five themes: technological tools, emergency remote learning, time, distraction of students, and assessment. The categories under each theme, the number of participants stated the relevant category, and the frequency of statements are given in Table 4.1.3.

Table 4.1.3 Challenges

Themes	**Categories**	**Number of participants (*n*)**	**Frequency (*f*)**
ICT competencies	Teachers' competencies	14	36
	Technical problems	10	21
	Students' competencies	7	15
	Collaborating with teachers	1	4
Emergency remote learning	Screen time	12	21
	Difficulty of classroom management	8	23
	Decrease in motivation	7	13
	Decrease in communication	5	7
	Challenge of learning the tools	3	7
	Difficulty of mathematics instruction	1	1
Time	Preparation of lesson	6	17
	Implementation in class	5	9
	Learning technology	5	8
Distraction of students		9	14
Assessment	Students' perspective	6	27
	Result focus	1	3

Total number of participants: 24

4.1.3.1 ICT Competencies

The first theme classified under challenges is technological tools. The opinions of teachers related to how ICT competencies can be a challenge were analyzed in terms of teachers' competencies, technical problems, students' competencies, and collaborating with teachers.

Teachers' competencies

According to the interviews held before teachers' participation in the online CoP, teachers' competencies are considered as a challenge in technology integration (*n*=14, *f*=36). Although the emergency remote learning period forced teachers to increase their competencies in ICT, their ICT skills were limited. This also became an obstacle for their technology integration practices. They agreed that their technology integration practices were very limited before the pandemic. In order to integrate technology in their classes, they considered that they should have had the necessary skills. In this regard, one of the teachers shared her opinion as follows:

> "I need to learn the program very well so that I can increase its impact on children. … I paid particular attention to this in myself: To choose a few programs well, to improve myself in them and to reach children in that sense. Here are the difficulties: There's a lot going on, choosing the right tool and progressing in a right way." [36]

Another aspect related to teachers' competencies is related to teachers' methods integrating technology. A teacher emphasized that she could not integrate technology into mathematics lessons effectively by stating the following:

> "Because, frankly, I do not think that I have been able to ensure that mathematics is integrated into them." [37]

Moreover, one of the teachers highlighted that she had lack of required skills for MS Office programs which caused longer hours for instructional preparation. Even in lesson planning, preparing presentations, worksheets and homework, teachers' competencies became a problem. A sample quote stating this problem is as follows:

> "I had such a hard time that one day I was able to sit down at noon and write only 6 questions until 6 pm because I could barely draw its shape. I needed to look for it, how it is done?" [38]

Technical problems

Another challenge that teachers encountered during technology integration is stated as technical problems (*n*=10, *f*=21). Accordingly, when teachers or students have some technical problems, it affected their way of planning. A sample quote in this regard is as follows:

> “The biggest annoyance is that your internet connection is not very good when you try to use something online. When yours or the child's is bad, you cannot establish a mutual communication.” [39]

Students’ competencies

While integrating technology, students’ competencies is regarded as another challenge (*n*=7, *f*=15). Accordingly, in order to make students benefit from technology while learning, they needed to have required skills with that technological tool. A teacher shared her opinion in this regard as follows:

> “Now, some children cannot be that competent, they have to make a membership, for example, in another system. The child could not do it. You have to explain it to the child one by one. Of course, this also causes a slowdown in our lesson plan.” [40]

Collaborating with teachers

Out of 24 teachers, only one teacher highlighted the role of collaborating with teachers (*f*=4). in technology integration practices. She considered the lack of teacher collaboration in technological tools as a challenge. Considering teachers’ skills and knowledge about different technological tools and their experiences about integrating these tools, collaboration was thought as an enabler in technology integration, especially in planning stage. In order to benefit from others’ experiences in technology integration, she highlighted the collaboration with both mathematics teachers and ICT teachers. A sample quote in this regard is as follows:

> “I know my objective in mathematics, but at the point of integration, I am stuck when it does not go with the ICT teacher. Otherwise, the teacher gives a different idea. There the implementation turns into something more beautiful.” [41]

4.1.3.2 Emergency Remote Learning

The second theme classified under challenges is emergency remote learning. The opinions of teachers related to how emergency remote learning was a challenge were analyzed in terms of screen time, difficulty in classroom management, decrease in motivation, decrease in communication, challenge of learning the tools, and difficulty of mathematics instruction.

Screen time

Findings indicated that long hours of screen time for both teachers and students were considered as a challenge during the emergency remote learning (n=12, f=21). Teachers mentioned that this screen time may have led students to addiction of technology. Because of the emergency remote learning period, all tasks within class and out of class required students to be in front of the screen which is not healthy in normal conditions. On the other hand, teachers stated their position in front of the screen all day by stating the following:

> “I'm not used to sitting anyway, normally we sit for about 2 minutes. Now, it is much more tiring to sit and lecture like this. I think it requires more effort like one and a half times.” [42]

Difficulty of classroom management

During the emergency remote learning, teachers’ classroom management became a challenge (n=8, f=23). While controlling students’ undesirable behaviors in classroom is easy, the remote environment made it difficult for teachers. One of the teachers shared her opinion in this regard as follows:

> “Even if we do not use any technological tools during the lesson, we deal with problems such as whether they open a game in the background, adapt to the lesson, turn on the camera.” [43]

Decrease in motivation

Another challenge is stated as decrease in students' motivation during the emergency remote learning period (*n*=7, *f*=13). Both remote learning and quarantine process had a negative impact on students' psychology. Hence, the learning environment was affected by the decrease in students' motivation negatively during the emergency remote learning period. A teacher shared her experience in this period by stating the following:

> "When it is online, their motivation for the math lesson decreases, their interest decreases, and they can get bored." [44]

Decrease in communication

Regarding the challenges that teachers encountered during the emergency remote learning period, communication is considered (*n*=5, *f*=7). Accordingly, teachers felt lack of communication, especially non-verbal communication, while maintaining their classes online. One of the participants stated her opinion in this issue as follows:

> "So, by looking into the eyes of the student, it is easier to see if he really understands something in the classroom setting." [45]

Challenge of learning the tools

The emergency remote learning period forced teachers to learn technological tools by themselves. Another theme extracted from the interviews about challenges is learning tools which they can use in online classes (*n*=3, *f*=7). A teacher shared her challenging learning process by stating the following:

> "We hear about Kahoot, we research it ourselves, we learned about Zoom, because we had to." [46]

Difficulty of mathematics instruction

One of the teachers stated that learning mathematics was very difficult in online classes because even in face-to-face classroom setting, students had struggles to learn mathematics (*f*=1). A sample quote in this issue is as follows:

> "Because it is very difficult to teach mathematics in distance education, which is a lesson that they have difficulty even in face-to-face, it is even more difficult from a distance." [47]

4.1.3.3 Time

The third theme classified under challenges of integrating technology is time. The opinions of teachers related to how time of technology integration was a challenge were analyzed in terms of preparation of lesson, implementation in class, and learning technology integration.

Preparation of lesson

One of the challenges that teachers encountered related to time is preparation of lesson integrating technology (*n*=6, *f*=17). Teachers mentioned the extra time required for planning a lesson integrating technology. A sample quote in this regard is as follows:

> "While we are making lesson plans, of course we include technology, but this means preliminary preparation. It requires a little bit more of the preliminary preparation we're doing. And this time this happens: We're making one, that was fine, but it would be better if it was like this. We need to devote more time to improving ourselves each time. We take a little more time from ourselves and deal with technology." [48]

Implementation in class

Another challenge related to time is the duration of implementing the lesson plans integrating technology in class (*n*=5, *f*=9). Teachers emphasized that they needed to check their availability to integrate technology in their lesson time because of the intense curriculum. A teacher shared her opinion in this issue by stating the following:

> "I think that the more we can use it, the better, if only my lesson time is suitable and does not leave me behind from the curriculum." [49]

Learning technology integration

The other point stated by teachers as a challenge in technology integration is the time for learning how to integrate technology (*n*=5, *f*=8). Accordingly, teachers' large number of classes in their program prevented them to allocate time for learning how to integrate technology in their classes, even if they had interest. A sample quote stating lack of time for professional development in technology integration is as follows:

> "I was curious but remained distant. Why? Due to lack of time… Due to our branch, our lesson hours are very busy, frankly, you do not have much time to spare for yourself. Therefore, I could not improve myself very much, but I was interested." [50]

4.1.3.4 Distraction of Students

The fourth theme classified under challenges of integrating technology is distraction of students (*n*=9, *f*=14). Teachers mentioned that when they integrate technology into their classes, they frequently observed that students' distraction. One of the teachers explained her experience in this regard as follows:

> "Mostly, they lose their attention to other things and they are disconnected from the content of the lesson at that moment. They move away from what I want to show." [51]

4.1.3.5 Assessment

The fifth theme classified under challenges is assessment. The opinions of teachers related to how assessment was a challenge while integrating technology were analyzed in terms of students' perspectives and result focus.

Students' perspectives

While integrating technology for assessing students' understanding, teachers mentioned that students' consideration of technology as a competitive game prevented to assess students' understanding effectively and provide the required feedback for them (*n*=6, *f*=27). This was considered as a challenge for teachers because they would like to see the results of the class. However, students focused on participating in the assessment as a game, they may have answered the questions randomly to compete in the speed or they may have not interested in listening the feedback provided by the teacher. A teacher shared her opinion in this issue as follows:

> "I find it difficult for myself to draw attention to the point of showing the truth or correcting the wrong." [52]

Result focus

Out of 24 teachers, only one of the teachers emphasized that assessing students' understanding in class with the help of applications provided only the results rather than the ways of thinking in that question (*f*=3). A sample quote explains this challenge in integrating technology for assessment by stating the following:

> "The drawback is that I can't see the steps of the solution for my own course. I can only see the result." [53]

4.1.4 Teachers' Experiences

Findings indicated teachers' experiences in classroom while teaching mathematics through two themes: approaches to mathematics instruction and perceived level of technology integration. The number of participants stated the relevant theme, and the frequency of statements are given in Table 4.1.4.

Table 4.1.4 Teachers' Experiences

Themes	**Number of participants (*n*)**	**Frequency (*f*)**
Approaches to mathematics instruction	7	14
Perceived level of technology integration	5	9

Total number of participants: 24

4.1.4.1 Approaches to mathematics instruction

The first theme classified under teachers' experiences is teachers' approaches to mathematics instruction (*n*=7, *f*=14). Most of the teachers mentioned that they followed a traditional approach in their classes, in which they lecture and solve questions. Mathematics was considered as a discipline requires practice with a pencil and paper. One of the teachers shared her teaching approach in this regard as follows:

> "Also, we do more operations in math class. We are solving questions." [54]

On the other hand, some of the teachers shared that they preferred in-class activities in which students played active roles. Accordingly, more student-based approaches were used in class. A sample quote in this regard is as follows:

> "That traditionalist approach has already been largely broken, but we can say that it does not exist now." [55]

One of the participants shared that she had lack of knowledge and skills to change traditional approach in mathematics classes and integrate technology by stating the following:

> "There are many different programs, of course, we do not know. They never showed it while we were studying at the university. I am also a graduate of the department of mathematics. I received a formation program, but the formation was given very quickly. You can approach education in a different way, get rid of the traditional method, make students love mathematics in this way, we have never seen them this way." [56]

4.1.4.2 Perceived level of technology integration

The second theme classified under teachers' experiences is teachers' perceived level of technology integration (*n*=5, *f*=9). Accordingly, teachers stated that they integrated technology in their classes in a limited way before the pandemic. So, the emergency remote learning period forced them to integrate. One of the teachers explained her situation by stating the following:

> "I personally don't think I integrate technology too much in math classes." [57]

4.2 The Knowledge Construction Levels in Online Discussions During the Implementation of the Online CoP

This part presents the answer for the first sub-question: What knowledge construction levels are observed in the online discussions during online CoP?

While participating in the online CoP, teachers attended online discussion activities through the learning management system. These discussion activities included the examination of two sample lesson plans and sharing of their opinions after the implementation of their lesson plans within small groups and main group. The knowledge construction levels of these online discussion recordings were analyzed based on Interaction Analysis Model (Gunawardena et al. 1997).

4.2.1 The Knowledge Construction Levels in Online Discussions Related to Examining Sample Lesson Plans

During the implementation of the online CoP, teachers examined two sample lesson plans integrating Excel and Scratch as cognitive tools and discussed their opinions based on the given questions in the activity. The knowledge construction levels of these online discussion recordings were analyzed based on Interaction Analysis Model (Gunawardena et al. 1997) and the results of online discussion activities related to examining lesson plans are given in Table 4.2.1.

Table 4.2.1 Knowledge Construction Levels in Online Discussions Related to Examining Sample Lesson Plans based on Interaction Analysis Model (Gunawardena et al. 1997)

Phases	**Knowledge Construction Levels**	**Number of participants (*n*)**	**Frequency (*f*)**
Phase I: Sharing/comparing of information	A. A statement of observation or opinion	23	353
	B. A statement of agreement from one or more other participants	16	50
	C. Corroborating examples provided by one or more participants	21	104
	D. Asking and answering questions to clarify details of statements	2	7
	E. Definition, description, or identification of a problem	13	53
Phase II: The discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements	A. Identifying and stating areas of disagreement	17	40
	B. Asking and answering questions to clarify the source and extent of disagreement	1	1
	C. Restating the participant's position, and possibly advancing arguments or considerations in its support by references to the participant's experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view	3	15
Phase III: Negotiation of meaning/co-construction of knowledge	A. Negotiation or clarification of the meaning of terms	-	-
	B. Negotiation of the relative weight to be assigned to types of argument	-	-
	C. Identification of areas of agreement or overlap among conflicting concepts	-	-
	D. Proposal and negotiation of new statements embodying compromise, co-construction	-	-
	E. Proposal of integrating or accommodating metaphors or analogies	-	-

Table 4.2.1 (Continued)

Phase IV: Testing and modification of proposed synthesis or co-construction	A. Testing the proposed synthesis against ‘‘received fact” as shared by the participants and/or their culture	-	-
	B. Testing against existing cognitive schema	-	-
	C. Testing against personal experience	-	-
	D. Testing against formal data collected	-	-
	E. Testing against contradictory testimony in the literature	-	-
Phase V: Agreement statement(s)/application of newly constructed meaning	A. Summarization of agreement(s)	2	9
	B. Applications of new knowledge	-	-
	C. Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the conference interaction	-	-

Sharing and comparing information during the examination of lesson plans

The first phase is ***sharing and comparing of information*** in knowledge construction. The results indicated that while examining sample lesson plans, most of the discussion messages were analyzed within this phase. According to the results of online discussion activities based on examining sample lesson plans, the messages mostly included teachers' *statement of observation or opinion* (*n*=23, *f*=353). A sample post in this knowledge construction level is as follows:

> "The lesson plan has been prepared in accordance with the principles of the Constructivist Learning Environments Model, making use of these principles. An unstructured problem context is created, and the problem situation is presented to the students in connection with their daily lives. In this plan, where the teacher remains as a guide, the students comprehend the outcome by examining the example situations, using information resources and the cognitive tool, and producing solutions to the problem." [58]

Out of 24 teachers, 16 teachers' messages contained *a statement of agreement from one or more other participants* (*f*=50), which is the second level in the first phase. For instance, an online discussion message in this regard is as follows:

> "As my T02 teacher said, I would like the ICT teacher to make preliminary preparations with the students." [59]

Another code within the messages was *corroborating examples provided by one or more participants* (*n*=21, *f*=104). In the following sample post, the teacher shared examples for the use of Excel as a cognitive tool within different subjects:

> "Creating tables and graphs with the help of Excel, calculating the arithmetic mean and span, or writing an integer instead of the unknown in algebraic expressions and calculating the value of the expression will be a motivational work for them." [60]

During the examination of lesson plans, out of 24 teachers, two teachers' discussion messages contained *asking and answering questions to clarify details of statements* (*f*=7). A sample post in this knowledge construction level is as follows:

> "T28 and T10 also stated that students can update their problem situations with situations that they consider important to them and that interest them. I think that the sample situations can be changed by considering the context and interests of the applied student group. What do you think?" [61]

While sharing and comparing information, teachers also stated *definition, description, or identification of a problem* (*n*=13, *f*=53) within their discussion messages. One of the teachers identified a possible problem in the sample lesson plan and stated as follows:

> "I think that various speed-time graphs shown to the students may attract the attention of some students whereas they intimidate some others." [62]

The discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements during the examination of lesson plans

The second phase is ***the discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements***. According to the results of online discussion activities based on examining sample lesson plans, the messages mostly included teachers' *identification and statement of areas of disagreement* (*n*=17, *f*=40) in this phase. A sample post in this knowledge construction level is as follows:

> "I would spread it out over 3 lecture hours so that there is sufficient absorption time for the topic and activities. After the activities, I would like the students to synthesize what they learned and create their own activities on the subject through group work. I would have other groups evaluate the activities presented as a group through rubrics." [63]

Out of 24 teachers, only one teacher's message contained *asking and answering questions to clarify the source and extent of disagreement* (*f*=1). A sample quote indicates her disagreement about the time for the given activity in the sample lesson plan and asked others about their ideas in this issue by stating the following:

> "Maybe the time could have been longer while preparing the lesson plan. Is self-study time sufficient for an average 8th grader?" [64]

There were discussion messages which were analyzed as *restating the participant's position, and possibly advancing arguments or considerations in its support by references to the participant's experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view* (*n*=3, *f*=15). Accordingly, a sample post indicates the restatement of a teacher's position related to the daily life example given in the lesson plan by referencing her experience with this group of students by stating the following:

> "For example, children are interested in mobile games and machine games in playgrounds. It is important for them to collect points while playing these games. I think that designing a subscription question to be used in game

subscriptions or machines in playgrounds as an activity subject will be more effective in motivating them. Although the examples given are directly related to daily life, they do not belong to the students' world enough to attract their attention." [65]

Agreement statement(s)/application of newly constructed meaning during the examination of lesson plans

According to the results, the discussion messages included *summarization of agreements* (*n*=2, *f*=9) in this phase. One of the sample posts in this knowledge construction level is as follows:

> "As teachers who comment, we all agree that the problem is given with a plan which is prepared in line with the principles in Jonassen's Constructivist Learning Environments Model and motivates students to learn. But also, we think that within this plan, students may get bored from time to time or they may lack Excel knowledge, and the time cannot be used efficiently. We have a consensus that when we create the lesson plan ourselves, we can extend the time…" [65]

4.2.2 The Knowledge Construction Levels in Online Discussions Related to the Implementation of Lesson Plans

During the implementation of the online CoP, after the examination of sample lesson plans, teachers planned and implemented their lesson plans integrating Excel and Scratch as cognitive tools and discussed their opinions based on the given questions in the activity. The knowledge construction levels of these online discussion recordings were analyzed based on Interaction Analysis Model (Gunawardena et al. 1997) and the results of online discussion activities related to implementation of lesson plans are given in Table 4.2.2.

Table 4.2.2 Knowledge Construction Levels in Online Discussions Related to the Implementation of Lesson Plans based on Interaction Analysis Model (Gunawardena et al. 1997)

Phases	**Knowledge Construction Levels**	**Number of participants (*n*)**	**Frequency (*f*)**
Phase I: Sharing/comparing of information	A. A statement of observation or opinion	20	189
	B. A statement of agreement from one or more other participants	10	20
	C. Corroborating examples provided by one or more participants	8	23
	D. Asking and answering questions to clarify details of statements	-	-
	E. Definition, description, or identification of a problem	15	56
Phase II: The discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements	A. Identifying and stating areas of disagreement	13	16
	B. Asking and answering questions to clarify the source and extent of disagreement	3	3
	C. Restating the participant's position, and possibly advancing arguments or considerations in its support by references to the participant's experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view	-	-
Phase III: Negotiation of meaning/co-construction of knowledge	A. Negotiation or clarification of the meaning of terms	-	-
	B. Negotiation of the relative weight to be assigned to types of argument	-	-
	C. Identification of areas of agreement or overlap among conflicting concepts	-	-
	D. Proposal and negotiation of new statements embodying compromise, co-construction	-	-
	E. Proposal of integrating or accommodating metaphors or analogies	-	-

Table 4.2.2 (Continued)

Phase IV: Testing and modification of proposed synthesis or co-construction	A. Testing the proposed synthesis against ‘‘received fact” as shared by the participants and/or their culture	-	-
	B. Testing against existing cognitive schema	-	-
	C. Testing against personal experience	-	-
	D. Testing against formal data collected	-	-
	E. Testing against contradictory testimony in the literature	-	-
Phase V: Agreement statement(s)/application of newly constructed meaning	A. Summarization of agreement(s)	5	103
	B. Applications of new knowledge	-	-
	C. Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the conference interaction	-	-

Sharing and comparing information after the implementation of lesson plans

The findings indicated that the posts of the participants were mostly for ***sharing or comparing information*** which represented the first phase of knowledge construction. Out of 24 teachers, 20 of teachers’ messages mostly included teachers’ *statement of observation or opinion* (*f*=189). A sample post in this knowledge construction level is as follows:

> “Thanks to the game they designed, it was observed that it was especially useful in making sense of the concept of variable. The sharing of ideas by the students with each other through group work was also an important element that reinforced peer learning.” [67]

During online discussions after the implementation of lesson plans, teachers stated their *agreement from one or more participants* (*n*=10, *f*=20) by indicating the similar experiences or opinions. For instance, an online discussion message in this regard is as follows:

> "I also agree with my T17 teacher. I agree with the idea that the hardest part is putting the estimation skills into coding." [68]

Another knowledge construction level within the messages was *corroborating examples provided by one or more participants* (*n*=8, *f*=23). In the following sample post, the teacher shared an example from the implementation of the lesson plan integrating Excel as a cognitive tool to indicate peer learning she observed:

> "Sharing the ideas of the students who found the result with different formulas was an important element that reinforced peer learning." [69]

Other observed knowledge construction level in the teachers' online discussion messages is *definition, description, or identification of a problem* (*n*=15, *f*=56). In this regard, a teacher shared her identification of a problem in implementing the lesson plans integrating Scratch as a cognitive tool by stating the following:

> "As shared by other teachers, all students must master the Scratch application and have completed their programming skills." [70]

The discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements after the implementation of lesson plans

The findings indicated that the participants shared posts for ***the discovery and exploration of dissonance or inconsistency*** which represented the second phase of knowledge construction. Teachers' messages in this level mostly included *identifying and stating areas of disagreement* (*n*=13, *f*=16). A sample post stating areas of disagreement related the time allocated for the implementation is as follows:

> "Since two hours were not enough, I would increase the course time and diversify the examples." [71]

Secondly, the discussion messages included *asking and answering questions to clarify the source and extent of disagreement* (*n*=3, *f*=3). For instance, one of the participants discovered a problem in the design of Scratch game and informed the other group members, added some conditions to consider for their implementations.

After that, another teacher shared the same problem by stating her disagreement. Then the teacher asked about her disagreement to clarify its extent by stating the following:

> "Good evening, teacher T18. I don't quite understand if you are talking about the part that we saw missing while practicing. Did you have a problem even though you added the required code?" [72]

Agreement statement(s)/application of newly constructed meaning after the implementation of lesson plans

The findings indicated that the participants shared posts for the *agreement statements/application of newly constructed meaning* which represented the fifth phase of knowledge construction. Teachers' messages in this level included summarization of agreements (*n*=5, *f*=103). A sample post indicating a summarization of agreements by a reporter of a small group is as follows:

> "It was observed that the implementation of the lesson plan required more than 2 lesson hours. Lesson time can be increased, and students can be given more time to think." [73]

4.2.3 The Knowledge Construction Levels in Online Discussions Related to Examining Other Groups' Lesson Plans

During the implementation of the online CoP, after the implementation and discussion of the lesson plans within small groups, teachers shared their lesson plans within the large group and each group shared their experiences related to their lesson plans with a synchronous session. After this session, each participant selected two lesson plans other than his/her group and shared their opinions by answering the questions in the activity through online discussion board. The knowledge construction levels of these online discussion recordings were analyzed based on Interaction Analysis Model (Gunawardena et al. 1997) and the results of online discussion activities related to examining other groups' lesson plans are given in Table 4.2.3.

Table 4.2.3 Knowledge Construction Levels in Online Discussions Related to Examining Other Groups' Lesson Plans based on Interaction Analysis Model (Gunawardena et al. 1997)

Phases	**Knowledge Construction Levels**	**Number of participants (*n*)**	**Frequency (*f*)**
Phase I: Sharing/comparing of information	A. A statement of observation or opinion	20	86
	B. A statement of agreement from one or more other participants	10	12
	C. Corroborating examples provided by one or more participants	10	18
	D. Asking and answering questions to clarify details of statements	-	-
	E. Definition, description, or identification of a problem	4	5
Phase II: The discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements	A. Identifying and stating areas of disagreement	8	13
	B. Asking and answering questions to clarify the source and extent of disagreement	-	-
	C. Restating the participant's position, and possibly advancing arguments or considerations in its support by references to the participant's experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view	-	-
Phase III: Negotiation of meaning/co-construction of knowledge	A. Negotiation or clarification of the meaning of terms	-	-
	B. Negotiation of the relative weight to be assigned to types of argument	-	-
	C. Identification of areas of agreement or overlap among conflicting concepts	-	-
	D. Proposal and negotiation of new statements embodying compromise, co-construction	-	-
	E. Proposal of integrating or accommodating metaphors or analogies	-	-

Table 4.2.3 (Continued)

Phase IV: Testing and modification of proposed synthesis or co-construction	A. Testing the proposed synthesis against ‘‘received fact” as shared by the participants and/or their culture	-	-
	B. Testing against existing cognitive schema	-	-
	C. Testing against personal experience	-	-
	D. Testing against formal data collected	-	-
	E. Testing against contradictory testimony in the literature	-	-
Phase V: Agreement statement(s)/application of newly constructed meaning	A. Summarization of agreement(s)	-	-
	B. Applications of new knowledge	-	-
	C. Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the conference interaction	-	-

Sharing and comparing information during the examination of other groups' lesson plans

The findings indicated that the posts of the participants were mostly for ***sharing or comparing information***. In this phase, out of 24 teachers, 20 teachers' messages included teachers' *statement of observation or opinion* (*f*=86). A sample post in this knowledge construction level is as follows:

> "Since the common divisor and common multiple is a subject that students have difficulties and difficult to grasp, I think that intertwining with information technologies will attract students' attention and make learning easier." [74]

During online discussions related to examining other groups' lesson plans, teachers stated their *agreement from one or more participants* (*n*=10, *f*=12) by indicating the similar experiences or opinions. For instance, an online discussion message in this regard is as follows:

> "This is how I would implement this plan, too." [75]

Another knowledge construction level within the messages was *corroborating examples provided by one or more participants* (*n*=10, *f*=18). In the following discussion message, the participant exemplifies the effect of the cognitive tool in helping students' understanding in specific topics and its help for understanding related topics in future by referencing to the lesson plan.

> "Students can better observe the difference between repeated addition and repeated multiplication. It may also be a preparation for the coming years." [76]

Other observed knowledge construction level in the teachers' online discussion messages is *definition, description, or identification of a problem* (*n*=4, *f*=5). In this regard, a teacher shared her agreement first but also underlined the problem of the lesson plan as a future consideration by stating the following:

> "This lesson plan has been a suitable plan which allows students use of mathematics in daily life, explore and enjoy, and I would implement this plan as it is. I would choose a period where I can use the time effectively in order not to have problems with the use of time regarding the related comments." [77]

The discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements during the examination of other groups' lesson plans

The findings indicated that the participants shared posts for ***the discovery and exploration of dissonance or inconsistency*** which represented the second phase of knowledge construction. Teachers' messages in this phase included *identifying and stating areas of disagreement* (*n*=8, *f*=13). A sample post stating areas of disagreement related to the integration of the cognitive tool is as follows:

> "If I were planning the same lesson, I would add a study (formula etc.) that would enable them to use Excel more actively." [78]

4.3 The Indicators of Technology Integration as Cognitive Tools in the Lesson Plans

This part presents the answer for the second sub-question: What are the indicators of technology integration as cognitive tools in the lesson plans designed by teachers?

The lesson plans designed by teachers during the online CoP were analyzed based on the checklist constructed by the researcher in order to indicate how teachers reflect the constructivist aspect of technology integration as cognitive tools. This checklist was designed based on Jonassen's Constructivist Learning Environments Model (1999) which was used in the online CoP. For deciding whether the lesson plan included related feature of the questions, for each question, criteria was identified based on the related literature (See Appendix D). The results are examined under seven categories that indicate constructivist learning environments: question/case/problem/project, related cases, information sources, cognitive tools, conversation/collaboration tools, social/contextual support, and instructional activities.

4.3.1 Question/Case/Problem/Project

According to Jonassen's Constructivist Learning Environment Model (1999), the lesson plans should be centered on a question, case, problem, or project. This component of the model was analyzed through six questions in the checklist. The findings were indicated in Table 4.3.1.

The checklist questioned whether the lesson plan was designed with ***a focus of a problem that students attempt to solve or resolve***. While investigating this feature, the lesson plans were checked to identify whether they included *a problem that constitutes a learning goal that students may accept or adapt* and whether *students are trying to learn the content through solving the problem* within the lesson plan. Findings indicated that all lesson plans were designed placing a problem that students attempt to solve or resolve. For instance, in one of the lesson plans, the students were expected to determine how many boxes the delivery people can carry at a time, considering the load carrying capacity of the elevator with the help of Excel. In this problem, while students are working on the solution of the problem, they need to consider the order of operations, which is one of the learning goals.

Table 4.3.1 The Findings for Question/Case/Problem/Project in The Lesson Plans

Items	**LP1**	**LP2**	**LP3**	**LP4**	**LP5**	**LP6**	**LP7**	**LP8**
	Y/N	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**
1.1. Is the lesson plan designed with a focus of a problem that learners attempt to solve or resolve?	Y	Y	Y	Y	Y	Y	Y	Y
1.2. Is the problem ill-defined or ill-structured?	Y	Y	Y	Y	Y	Y	Y	Y
1.3. Is the problem authentic that contains tasks replicating the particular activity structures of a context?	Y	Y	Y	Y	Y	Y	Y	Y
1.4. Is the problem given with its context?	Y	Y	Y	Y	Y	Y	Y	Y
1.5. Is the problem represented to the learners in an interesting, engaging, and appealing way?	Y	Y	Y	Y	Y	Y	Y	Y
1.6. Do the activities contain problem manipulation spaces that enable learners to test the effects of their manipulations?	Y	Y	Y	Y	Y	Y	Y	Y

**Y: Yes N: No*

***LP1, LP2, LP3, LP4, LP5, LP6, LP7, LP8: Lesson Plan 1, 2, 3, 4, 5, 6, 7, 8*

Another item in this part searched for whether the lesson plan included *an ill-defined or ill-structured problem*. Jonassen (1997) described the features of ill-structured problems as follows:

- Have unstated goals and constraints
- Possess multiple solutions, solution paths, or no solutions at all
- Possess multiple criteria for evaluating solutions
- Present uncertainty about which concepts, rules, and principles are necessary for the solution or how they are organized

- Offer no general rules or principles for describing or predicting the outcome of most cases
- Require learners to make judgement about the problem and to defend their judgements by expressing personal opinions or beliefs.

When the lesson plans were analyzed accordingly, all of them set up around a problem scenario without stating the learning goal directly. Hence, students were expected to solve the problems by dealing with uncertainty about which concepts, rules, and principles. None of the problems were examples of story problems that students are used to solve with following familiar procedures. All of the lesson plans included activities requiring students to make judgement about the problem and defend their judgements.

Whereas the common school tasks in mathematics are considered well-structured problems requiring some specific procedures (Van Merrienboer, 2013), the problems in the lesson plans produced by teachers were not problems requiring some operations which they were familiar. The students were involved in problems such as deciding the schedule of television programs considering the given conditions by using the knowledge of common multiples. Even though the problems did not possess multiple solutions or were not unsolvable, some of them allow students different solution paths. The interviews also indicated teachers' observations of different solution paths. A sample quote in this regard is as follows:

> "While we were applying our Excel lesson plan in the classroom, one of our students said: Teacher, we can shorten this formula. I never told them that." [79]

The lesson plans did not state multiple criteria for the evaluation of solutions. The evaluation of the problem-solving process, the participation of students, and the artifact were not described in the lesson plans.

The problems were ***authentic that contain tasks replicating the particular activity structures of a context and given with its context***. For instance, in some of the lesson plans, students were expected to design games on Scratch with the stated conditions. One of them was based on an illusionist's secret which helps to estimate the dates of birth as month and day. Using the secret algebraic expression, they were expected to design a game by thinking each step of the game as if they were a programmer and were involved in same type of cognitive challenges in the real world. In another lesson plan, students were expected to evaluate solutions of two students, in which one of them has a misconception about exponential numbers, as taking the role of a science teacher.

The lesson plans were analyzed to identify whether ***the problem is given with its context***. During the analysis, the following criteria was examined:

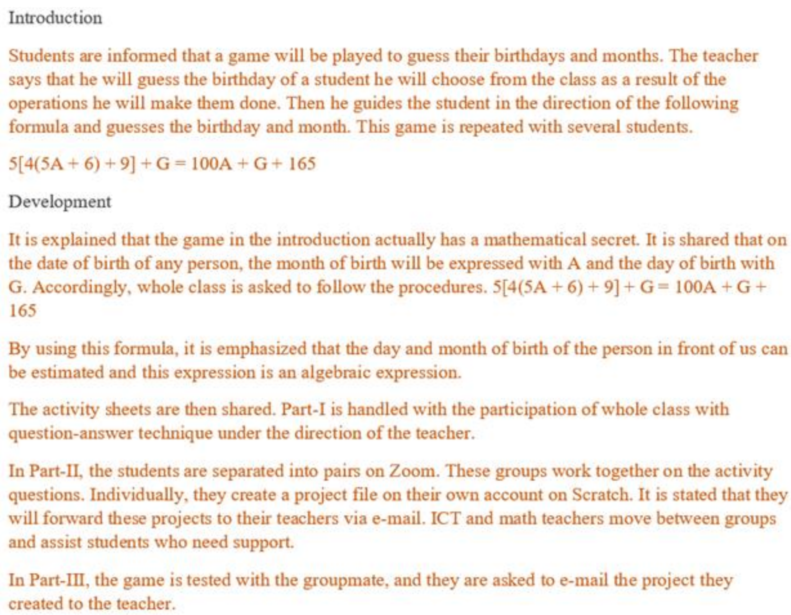
- A story about a set of events that leads up to the problem that needs to be resolved
- Description of the physical, socio-cultural, and organizational climate surrounding the problem

According to the findings of the analysis, all the lesson plans were given with its context. For instance, in one of the lesson plans, the story of two delivery person leaded the students to the problem. Another lesson plan considered a road trip and the problem of deciding the closest gas station on the road based on their location on the road. The stories in the introduction parts of the lesson plan described the physical, socio-cultural, and organizational climate surrounding the problem which let students understand the problem.

Based on the analysis of whether ***the problems represented to the learners in an interesting, engaging, and appealing way***, it can be said that the lesson plans included interesting problem scenarios for students. In this analysis, the problems were examined based on its relevancy or appeal to the learner and presentation of the problem in a natural context. For instance, one of the lesson plans started with a question "What are the decimal numbers you encountered while grocery shopping?" Then students were asked to consider how they decide to total amount they need to pay before the payment point, and the need for estimation and rounding decimals were highlighted. After this discussion, they were asked to design a program on Scratch that helps to round decimal numbers based on the digit values.

Throughout the plans, students were given to ***problem manipulation spaces*** in which students test the effects of their manipulations. While analyzing problem manipulation spaces, the activities were examined to identify whether *the students manipulate something (construct a product, manipulate parameters, make decisions) and affect the environment in some way* and whether *there are causal models that enable students to test the effects of the manipulations*. In one of the lesson plans, students are asked to determine how many boxes the delivery people can carry at a time, considering the carrying capacity of the elevator with the help of Excel. They were expected to formulize the total weight based on the parameter of the number of boxes. By changing the number of boxes, they could decide the maximum number of boxes that a delivery person can carry at a time considering the delivery person's weight. They can manipulate the parameter, see the result on Excel, and decide accordingly. Another example indicates the ill-structured problem that students work on, the product they produced and its test process (Figure 4.3.1.). A sample excerpt from one of the lesson plans is as follows:

> "In accordance with the stated objectives, students discover the algebraic expression that an illusionist uses in his demonstration. Then, they design a game that shows how the illusionist uses the algebraic expression that creates his secret in his demonstration, and they test the related game." Group1_Lesson_Plan_Scratch


Introduction

Students are informed that a game will be played to guess their birthdays and months. The teacher says that he will guess the birthday of a student he will choose from the class as a result of the operations he will make them done. Then he guides the student in the direction of the following formula and guesses the birthday and month. This game is repeated with several students.

$5[4(5A + 6) + 9] + G = 100A + G + 165$

Development

It is explained that the game in the introduction actually has a mathematical secret. It is shared that on the date of birth of any person, the month of birth will be expressed with A and the day of birth with G. Accordingly, whole class is asked to follow the procedures. $5[4(5A + 6) + 9] + G = 100A + G + 165$

By using this formula, it is emphasized that the day and month of birth of the person in front of us can be estimated and this expression is an algebraic expression.

The activity sheets are then shared. Part-I is handled with the participation of whole class with question-answer technique under the direction of the teacher.

In Part-II, the students are separated into pairs on Zoom. These groups work together on the activity questions. Individually, they create a project file on their own account on Scratch. It is stated that they will forward these projects to their teachers via e-mail. ICT and math teachers move between groups and assist students who need support.

In Part-III, the game is tested with the groupmate, and they are asked to e-mail the project they created to the teacher.

Figure 9 The screenshot of the sample lesson plan

4.3.2 Related Cases

The lesson plans should contain related cases that help the students apply the similar approach for the solution of the problem into other problems according to Jonassen's Constructivist Learning Environments Model (1999). This component of the model was analyzed through one question in the checklist. The findings were indicated in Table 4.3.2.

Table 4.3.2 The Findings for Related Cases in The Lesson Plans

Items	**LP1**	**LP2**	**LP3**	**LP4**	**LP5**	**LP6**	**LP7**	**LP8**
	Y/N	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**
2.1. Does the lesson plan provide related cases or worked examples to enable case-based reasoning and enhance cognitive flexibility?	N	Y	Y	Y	N	Y	Y	N

**Y: Yes N: No*

***LP1, LP2, LP3, LP4, LP5, LP6, LP7, LP8: Lesson Plan 1, 2, 3, 4, 5, 6, 7, 8*

While analyzing the related cases or worked examples, the lesson plans were investigated to identify whether they provide one of the following criteria:

- A similar case, help students map the previous experience and its lessons onto the current problem
- A variety of viewpoints and perspectives on the case or project being solved.

Findings indicated that majority of lesson plans included *related cases to enhance cognitive flexibility of students*. These related cases were given after the solution of the problem to help students see a variety of viewpoints and perspectives on the case being solved. They highlighted the relationship of mathematics with daily life. For instance, in one of the lesson plans, the students were expected to work on different with 10, 100 and 1000. In one case, they worked on transforming length measurement units such as kilometers to meters. In another case, they worked on calculating the price of 1000 items with the help of the game they designed on Scratch. While working on the different contextual problems, students were given chance to combine their prerequisite knowledge in mathematics and ICT. For instance, they defined what steps were required to design the game on Scratch. They associated the required steps with mathematics. The solution of the ill-structured problems in the lesson plans made them combine different knowledge domains and relate different contexts, which contributed to students' cognitive flexibility. Within the lesson plans, there were not any similar case to help students map the previous experience and its lessons onto the current problem, which is scaffolding memory/case-based reasoning.

Only three lesson plans did not give place any other related case. In two of them, the lesson plans mentioned that in the assessment part, there would be given related problems in which students apply a similar solution approach. However, the assessment parts did not contain any similar problems. A sample excerpt from one of them is as follows:

"After the problems that the students have dealt with through the related activities, different examples where they can apply similar solutions are discussed in the evaluation section." [81]

4.3.3 Information Sources

The lesson plans should contain information sources that help students construct their mental models and formulate hypotheses for the solution of the problem according to Jonassen's Constructivist Learning Environments Model (1999). This component of the model was analyzed through three questions in the checklist. The findings were indicated in Table 4.3.3.

Table 4.3.3 The Findings for Information Sources in The Lesson Plans

Items	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8
	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
3.1. Does the lesson plan provide learner-selectable information just-in-time?	Y	Y	Y	Y	Y	Y	Y	Y
3.2. Do the lesson activities include relevant information?	Y	Y	Y	Y	Y	Y	Y	Y
3.3. Do the lesson activities include accessible information?	Y	Y	Y	Y	Y	Y	Y	Y

**Y: Yes N: No*

***LP1, LP2, LP3, LP4, LP5, LP6, LP7, LP8: Lesson Plan 1, 2, 3, 4, 5, 6, 7, 8*

While analyzing whether the lesson plan provides that *learner-selectable information just-in-time*, the information in the problem representation and extra resources that help students interpret the problem was investigated. For the second question in the checklist which is based on *relevant information*, the lesson plans were analyzed to identify whether the lesson plan provide relevant hints and related sources. In order to decide whether it includes *accessible information*, the accessibility of the information was evaluated.

Regarding these criteria, findings indicated that all of lesson plans included information sources to help students access and use the relevant information for the solution of the problem. While the lesson plans contained the relevant information in the problem representation, mathematics and ICT teachers provided some hints and reminders to scaffold their understanding during the implementation which allows students access information. Moreover, for readiness of students, teachers planned activities before the implementation of the lesson plans which is both related to accessibility and relevant information.

A sample excerpt from the lesson plans indicating how it included information sources for students is as follows:

> "The information necessary for the solution of the problem and the sources that can be referenced are shared with the students. (Activity sheet with details about the problem situation, a reminder document about using Excel, etc.) In the light of this information and resources, students make and test various assumptions." [82]

4.3.4 Cognitive Tools

The lesson plans should contain cognitive tools that help students understand and solve the problems and create an artifact according to Jonassen's Constructivist Learning Environments Model (1999). This component of the model was analyzed through six questions in the checklist. The findings were indicated in Table 4.3.4.

Regarding the use of Excel and Scratch as cognitive tools, the role of cognitive tools in the lesson plans differed.

While searching for the first question, the lesson plans were analyzed whether they include a product designed by students with the help of the cognitive tool. Accordingly, all the lesson plans provided *tasks that require cognitive tools to design and build artefacts*. A sample excerpt indicating how the lesson plan positioned Scratch as a cognitive tool to create a product is as follows:

> "At the end of this lesson plan, the student is expected to do some programming using Scratch decimal analysis skills. In this product, the

student will both create a product using what they know and will be able to generalize by making various experiments on this product." [83]

Table 4.3.4 The Findings for Cognitive Tools in The Lesson Plans

Items	**LP1**	**LP2**	**LP3**	**LP4**	**LP5**	**LP6**	**LP7**	**LP8**
	Y/N	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**
4.1. Do the lesson activities provide learners tasks that require cognitive tools to design and build artefacts?	Y	Y	Y	Y	Y	Y	Y	Y
4.2. Do the lesson activities provide learners tasks that require cognitive tools to organize and represent what they already know?	Y	Y	Y	Y	N	Y	Y	N
4.3. Do the lesson activities provide learners tasks to negotiate meaning through cognitive tools?	Y	Y	Y	Y	Y	Y	Y	Y
4.4. Do the lesson activities provide learners cognitive tools to transcend the limitations of their minds, such as limitations to memory, thinking, or problem solving?	Y	Y	Y	Y	Y	Y	Y	Y
4.5. Do the lesson activities provide learners cognitive tools to scaffold their thinking?	Y	Y	Y	Y	Y	Y	Y	Y
4.6. Do the lesson activities provide learners tasks to reflect on the activity through cognitive tools?	Y	Y	Y	Y	Y	Y	Y	Y

**Y: Yes N: No*

***LP1, LP2, LP3, LP4, LP5, LP6, LP7, LP8: Lesson Plan 1, 2, 3, 4, 5, 6, 7, 8*

For the second question, the lesson plans were analyzed whether they help students articulate and represent what they know with the help of cognitive tools. Based on the findings of the analysis, it was seen that most of the lesson plans included activities that *require cognitive tools to organize and represent what they already know*. A sample excerpt indicating how the lesson plan positioned Excel as a cognitive tool to organize and represent information is as follows:

"At the end of this lesson, in line with the learning outcome, students are expected to establish the common multiple relationship between different natural numbers. While establishing this relationship, it is expected that the numbers will determine their own multiples, enter these multiples into Excel, and determine the common multiples of two or three natural numbers by creating a table with the help of Excel." [84]

For the third question, the lesson plans were analyzed whether they provide tasks that support students' internal negotiations and meaning making. Accordingly, the findings indicated that all the lesson activities provided students tasks to negotiate meaning through cognitive tools, reflect on the activity, and scaffold their thinking through cognitive tools. In the following excerpt from one of the lesson plans integrating Excel as a cognitive tool, the activity helped students negotiate the difference of $2a$, 2^a, and a^2, reflect on the activity, and scaffold their thinking in a topic which students frequently confused with the help of the cognitive tool:

> "Accordingly, Arda and Özge wanted to predict how many fruit flies there will be after five weeks, when they have two fruit flies in the first week. Starting from the first week, Arda considered the first 5 weeks as 2, 4, 6, 8 and 10, respectively; Özge thought as 2, 4, 8, 16, 32.
>
> a) In this direction, create the fruit fly population estimates of Arda and Özge by week using Excel with a table.
>
> b) Which one thinks correctly? In other words, which chart shows that the fruit fly population is doubling every week?
>
> c) What does the inaccurate table represent?
>
> d) Specifying a as the number of weeks, create a table showing the values "$2a$", "2^a" and "a^2".
>
> e) Which expression refers to Arda's painting? Which expression refers to Özge's painting?
>
> f) Which expression increments the values the fastest when we replace a with values from 0 to 5?

> g) Create the graphs of the three expressions in the table you created in d, according to the weeks, and associate the graphs with your answers in f option." [85]

For the fourth question, the lesson plans were analyzed to identify whether they engage learners in new forms of thinking, extent their thinking process, and enable new forms of knowledge representation and task manipulation. The findings indicated that there are lesson activities provided learners *cognitive tools to transcend the limitations of their minds, such as limitations to memory, thinking, or problem solving* in all of the lesson plans. A sample excerpt indicates that students' programming a game that shows the place of a given fraction by referencing 0, ¼, ⅓, ½, and 1 help students develop estimation skills by transcending the limitations of their minds as follows:

> "At the end of this course, students are expected to be able to make predictions in a problem with fractions by relating the given fractions to fractions such as quarters, thirds, and halves. Accordingly, at the end of the lesson, they will design a game in Scratch. In the game, they are asked to guess which of the fractions given between 0 and 1 falls on the number line, such as 0 and a quarter, a quarter and a third, and a third and a half. After this estimation, they are asked to decide which fraction is closer to the fraction. Students will be provided to produce a game that they can develop by observing their estimation skills." [86]

The fifth question asks whether the lesson plans provide cognitive tools to *scaffold their thinking*. The lesson plans were analyzed to identify whether the cognitive tools engaged students in deeper levels of thinking and reasoning, such as causal, analogical, expressive, experiential, and problem solving. Accordingly, all the cognitive tools in the lesson plans help students engage in deeper levels of thinking and reasoning. For instance, in one of the lesson plans, students were expected to plan flights of two airway companies based on the given conditions of the airport. After identifying the common times of two companies in a day, they were asked to establish a mathematical relationship based on the concept of the least common multiple. With the help of Excel, students could see the relationship easily. It took a role of scaffolding their thinking.

The sixth question looks for whether the lesson plans provide learners tasks *to reflect on the activity through cognitive tools*. During the analysis, the lesson plans were examined to determine whether there are tasks to help students reflect on what they have learned and how they came to know it. Findings indicated that all the lesson plans provided such tasks requiring reflection through the cognitive tools. In one of the lesson plans, students were asked to design a game with Scratch indicating the which gas station is the closest based on the given location. While designing, students were expected to consider which steps they should follow and why they are important. They reflected on these steps. After the game is developed on Scratch, they tested the game and reflected on their findings.

4.3.5 Conversation/Collaboration Tools

The lesson plans should contain conversation and collaboration tools that help students work in groups according to Jonassen's Constructivist Learning Environments Model (1999). This component of the model was analyzed through one question in the checklist. The findings were indicated in Table 4.3.5.

Table 4.3.5 The Findings for Conversation/Collaboration Tools in The Lesson Plans

Items	**LP1**	**LP2**	**LP3**	**LP4**	**LP5**	**LP6**	**LP7**	**LP8**
	Y/N	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**
5.1. Do the lesson activities provide conversation and collaboration tools to support discourse communities, knowledge-building communities, and/or communities of learners?	Y	Y	Y	Y	Y	Y	Y	Y

**Y: Yes N: No*

***LP1, LP2, LP3, LP4, LP5, LP6, LP7, LP8: Lesson Plan 1, 2, 3, 4, 5, 6, 7, 8*

In order to examine conversation/collaboration tools in the lesson plans, the activities or tools supporting the following were analyzed:

- Collaboration within a group of participants
- Shared decision making about how to manipulate the environment
- Alternative interpretations of topics and problems
- Articulation of learners’ ideas
- Reflection on the processes they used.

Findings indicated that all of lesson plans included ***conversation and collaboration tools***. Since the lesson plans implemented during the emergency remote learning period, teachers planned pair or group activities with the help of breakout room feature of the video conferencing tools. While working on the artifact and the problem, students collaborated, shared their ideas, decided what to do, and tested their artifacts. A sample excerpt from one of the lesson plans in this regard is as follows:

> “The lesson is planned in a distance education environment where students can work collaboratively, interact and communicate with each other (due to the pandemic). Students have tasks in pairs.” [87]

Only a few of the teachers could implement the lesson plans in school environment. In these cases, teachers planned the ICT lab conditions in a way that allows students to work in pairs. On the other hand, one of the teachers also stated that he could implemented the lesson plan integrating Excel without grouping the students although the lesson plan was planned with collaborative tasks for the online environment. He explained that they could not implement the activities in pairs because some of the students attended online classes with mobile phones or tablets which prevented them to be involved in Excel tasks.

4.3.6 Social Contextual Support

The lesson plans should consider social contextual support that help both students and teachers involve in constructivist learning environments according to Jonassen's Constructivist Learning Environments Model (1999). This component of the model was analyzed through one question in the checklist. The findings were indicated in Table 4.3.6.

Table 4.3.6 The Findings for Conversation/Collaboration Tools in The Lesson Plans

Items	LP1	LP2	LP3	LP4	LP5	LP6	LP7	LP8
	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N	Y/N
6.1. Do the lesson activities provide social/contextual support for the learning environment?	Y	Y	Y	Y	Y	Y	Y	Y

**Y: Yes N: No*

***LP1, LP2, LP3, LP4, LP5, LP6, LP7, LP8: Lesson Plan 1, 2, 3, 4, 5, 6, 7, 8*

In order to examine social contextual support in the lesson plans, the following were analyzed:

- Accommodating environmental and contextual factors for the implementation
- Pretraining of the teachers about the tools
- Pretraining of the students about the tools
- Integrating ICT teachers into the planning process

Findings indicated that all of lesson plans included ***social contextual support***. The lesson plans contained the preliminary preparations for the cognitive tool including readiness activities, the video conferencing tool, breakout rooms, and support for students during the implementation. A sample excerpt from one of the lesson plans is as follows:

"Since this course will take place online, each student attends the course with their own computer via the Zoom program. Scratch can be accessed via a browser and each student is requested to create an account in advance and share the project file through this account. After connecting to the lesson, the activity sheet should be shared on the screen. Preliminary preparations have been made for Scratch. Students who need support are provided with the necessary support by the ICT and mathematics teacher." [88]

4.3.7 Instructional Activities

According to Jonassen's Constructivist Learning Environments Model (1999), teachers' instructional activities should include modeling, coaching, and scaffolding in constructivist learning environments. The model suggests that learning activities for exploration, articulation and reflection, teachers provide support by modeling, coaching, and scaffolding. This component of the model was analyzed through three questions in the checklist. The findings were indicated in Table 4.3.7.

Table 4.3.7 The Findings for Information Sources in The Lesson Plans

Items	**LP1**	**LP2**	**LP3**	**LP4**	**LP5**	**LP6**	**LP7**	**LP8**
	Y/N	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**	**Y/N**
7.1. Are there any activities that requires teachers' modeling?	N	Y	Y	N	N	N	Y	N
7.2. Are there any activities that requires teachers' coaching?	Y	Y	Y	Y	Y	Y	Y	Y
7.3. Are there any activities that requires teachers' scaffolding?	Y	Y	Y	Y	Y	Y	Y	Y

**Y: Yes N: No*

***LP1, LP2, LP3, LP4, LP5, LP6, LP7, LP8: Lesson Plan 1, 2, 3, 4, 5, 6, 7, 8*

Findings indicated that coaching and scaffolding activities were seen in the lesson plans whereas modeling was not seen obviously. While analyzing instructional activities in the lesson plans, ***teachers' modeling activities*** were examined in terms of *modeling performance* and *articulate reasoning*. Out of eight, only three lesson plans showed modeling activities in which teachers model behaviors in the performance and articulate the reasoning in the activities. In these lesson plans, students were given activity sheets and asked to work in pairs first. Then they turned to the main group. In the main group, the teachers modeled the performance for them by emphasizing both what to do and why to do that step relating with mathematics. A sample excerpt from one of the lesson plans for modeling is as follows:

> "After returning to the main group, Activity-1 is reviewed collectively. Then, returning to the groups in the same way, it is stated that they will work on Activity-2." [89]

For ***teachers' coaching activities***, the lesson plans were examined in terms of *providing motivational prompts*, *monitoring, and regulating the learners' performance*, *provoking reflection by asking questions*, and *perturbing learners' models*. In the instructional activities stated in the lesson plans, problem-solving, question-answer technique, exploration, and collaborative learning were stated. In these instructional activities, teachers provide coaching for students by monitoring and regulating their performance, providing motivational prompts, provoking reflection, and perturbing their models. A sample excerpt from one of the lesson plans for coaching is as follows:

> "Students are given sufficient time to think about the rules they want to write in the excel program, and they are asked to share their screens and interactively necessary directions are given to them." [90]

For ***teachers' scaffolding activities***, the lesson plans were examined in terms of *adjusting task difficulty*, *restructuring a task to supplant knowledge*, and *providing alternative assessments*. All the lesson plans included some activities related to scaffolding. For instance, in some of the lesson plans, the hints for students were written to support their progress in the problem solving. Moreover, the lesson plans mentioned the roles of ICT and mathematics teachers during the implementation in term of providing necessary support which may involve redesigning the task in a way that supports learning or adjusting task difficulty to help students understand. A sample excerpt from one of the lesson plans for scaffolding is as follows:

> "During the lesson, both the math teacher and the ICT teacher supervise the work of the groups, guide them and provide support to students who need it." [91]

For adjusting task difficulty, the design of the lesson plans can be considered. All the lesson plans included step-by-step activities which allows students to proceed by thinking critical elements of the problem. A sample excerpt from one of the lesson plans indicating the steps guiding students to reach a generalization in this regard as follows:

> "Set a number with your group mate and test the program you wrote. What is the number you have determined? What did you observe when you multiplied the number you determined by 10, 100 and 1000? What generalization can be made when you multiply a decimal number by 10, 100, and 1000?" [92]

On the other hand, there is no lesson plan providing alternative assessments. Although the activities within the lesson plans contained the information of what the task required of them, the assessment of the process and product was not stated overtly in the lesson plans. Some of the lesson plans included well-structured questions that aims to measure student learning at the end of the lesson. Most of them included statements indicating that the products of the students were collected at the end. Two of them mentioned the self-assessment; one was based on the evaluation of the product with a checklist and the other included evaluation of both the product and process, including elements such as what they learned, participation and effort for learning. However, both of them did not provide the details of the evaluation.

4.4 The Opinions of Teachers on the Impact of Participation in Online CoP on Their Technology Integration Practices as Cognitive Tools

This part presents the answer for the third question: What are the opinions of teachers on the impact of participation in online CoP on their technology integration practices as cognitive tools?

The opinions of the teachers about the impact of teacher professional development program were collected through interviews after their participation of online CoP about technology integration as cognitive tools. The results are examined under six themes: constructivist learning environments, maintaining online CoP, gains from online CoP, teachers' opinions related to teacher professional development, change in opinions related to technology integration, and technology integration prior to the participation in the online CoP.

4.4.1 Constructivist Learning Environments

The opinions of the teachers about constructivist learning environments were analyzed as a guide for technology integration as cognitive tools. The results of these analyses have been reported in six themes: the effect on students' learning, integration of cognitive tools, challenges of integrating cognitive tools, readiness of students, teachers' role in constructivist learning environments, and change in students' attitudes. The categories under each theme, the number of participants stated the relevant category, and the frequency of statements are given in Table 4.4.1.

Table 4.4.1 Constructivist Learning Environments

Themes	**Categories**	**Number of participants (*n*)**	**Frequency (*f*)**
The effect on students' learning	Learner attention and motivation	24	183
	Constructionism	24	119
	Understanding	22	135
	Active participation	22	68
	Integration of mathematics and daily life	21	71
	Integration of mathematics and technology	20	55
	Collaboration	12	38
	Developing thinking skills	11	18
	Easing task	4	9
	Autonomous learners	1	2

Table 4.4.1 (Continued)

Integration of cognitive tools	Willingness	21	100
	Increasing duration of lessons	19	67
	Integrating to yearly plan	17	73
	Determining appropriate cognitive tools	17	56
	Face to face implementation	17	39
	Desire to implement peers' lesson plans	16	43
	Desire to use variety of cognitive tools	9	27
	Planning with ICT teachers	9	18
	Desire to share with others	6	21
	Working with different grades	5	13
	Integrating cognitive tools in different subjects	5	11
	Assessment	1	11
	Designing shorter sample lesson plans	1	2
Challenges of integrating cognitive tools	Teachers' competencies	21	70
	Online implementation	19	62
	Extra time for planning	18	56
	Curriculum	12	57
	Preparing students to the national exams	8	35
	Limited ICT lesson duration	3	19
	Workload of ICT teachers	2	7
Readiness of students	ICT readiness	23	145
	Mathematics readiness	10	25
Teachers' role in constructivist learning environments	Support for students	14	45
	Facilitation	12	37
	Classroom management	2	5
Change in students' attitudes	Towards ICT	11	20
	Towards mathematics	6	16

Total number of participants: 24

4.4.1.1 The Effect on Students' Learning

The first theme classified under constructivist learning environments is the effect on students' learning. The opinions of teachers related to how integrating cognitive tools affected students' learning were analyzed in terms of learner attention and motivation, constructionism, understanding, active participation, integration of mathematics and daily life, integration of mathematics and technology, collaboration, developing thinking skills, easing task, and autonomous learners.

Learner attention and motivation

Interviews indicated that integrating cognitive tools in mathematics lessons increased students' attention and motivation (n=24, f=183). All participants emphasized learner attention and motivation in constructivist learning environments. While some of them stated that novelty of integrating cognitive tools attracted learners' attention and motivated them, some others suggested that integrating technology attracted learners' attention in every approach, traditional or constructivist. One of the teachers explained her perspective why students are motivated by technology integration by stating the following:

> "Because they are much more interested, curious and can do better than us." [93]

Another sample quote indicates how the novelty of cognitive tools affected students' attention in mathematics lesson:

> "On the positive side, doing something different once attracted their attention." [94]

On the other hand, a participant compared the traditional approach in mathematics classes and the role of integrating cognitive tools with an effective lesson plan by stating the following:

> "Because we may not be able to fully attract the attention of the student in situations that we talk about verbally, but when we prepare an effective lesson plan and introduce such a tool into the lesson, it definitely arouses more curiosity in the students. We have already seen this in our implementations." [95]

Regarding learner motivation in constructivist learning environments, two different situations were also discussed by the participants. One of them is that both high-achievers and low-achievers in mathematics are motivated by the constructivist learning environments. A sample quote in this regard as follows:

> "In other words, we had students who had academic difficulties in that objective, but we noticed that they were also more interested in the lesson." [96]

The other situation mentioned by teachers is that students who have not enough ICT readiness or interest in ICT had some motivation problems. A participant shared her observation in this issue as follows:

> "Not in general, but I observed this in a few students. Because they had difficulties in Excel and Scratch, and especially in Scratch, I observed that their motivation decreased in that instant within the lesson." [97]

Constructionism

Another theme extracted from interviews regarding the effect of constructivist learning environment on students' learning is constructionism (n=24, f=119). All participants agreed on that creating a product by using cognitive tools while discovering mathematical relationships had a positive effect on students' learning, motivation, and retention.

Teachers emphasized the effectiveness of constructivist learning environments on students' learning. While students were working on a daily life problem, they benefited from a technology and did mathematical reasoning by themselves. It helped them learn the concept better which makes the lesson more effective. A teacher stated her perspective in this regard by comparing this approach with traditional approach as follows:

> "A cognitive tool, that is, a technology that they will use becomes even more effective. The student is accustomed to the steps that the teacher usually

> shows and makes them do. In these plans, the student always used his own technology, tried it himself and produced solutions." [98]

Moreover, constructionism in these lesson plans helped students stay motivated and remember what they discovered in the long term according to the interviews. One of the participants highlighted the effect of constructionism on students' motivation and retention as follows:

> "They like it more because they do it themselves, and it stays in their minds more." [99]

Understanding

Interviews indicated that integrating cognitive tools in mathematics lessons helped students' understanding topics (*n*=22, *f*=135). Majority of participants highlighted that cognitive tools made the abstract topic easier to understand through visualizing and concretizing. One of the participants stated her perspective in this regard as follows:

> "With technology, there are points that the child can grasp and understand much better." [100]

Teachers agreed on using cognitive tools with a good planning to help students understand the abstract topics that they find difficult, or they have misconceptions about it. One of the teachers shared her experience in this study by stating the following:

> "The same thing happened in Excel. In the area calculation, they discovered that the product of them will be 48 for all of them. So, when they have a table in front of them like this in Excel, they can solve it much faster when they get it visually." [101]

On the other hand, since it requires more time for planning, choosing the right topics that technology contribute their understanding was considered as more important. A sample quote in this issue is as follows:

> "If we wanted to associate it with such simpler topics, perhaps this effort we spent on the preparation process would have been wasted. It is very important to get support from a cognitive tool on a more complex subject that the student has difficulty in understanding." [102]

Active participation

Out of 24, 22 teachers stated that constructivist learning environments gave chance to students to participate actively in the lesson (*f*=68). One of the participants shared her opinion in this regard as follows:

> "Of course, a lesson in which the student is involved, expresses his/her opinion, contributes to the functioning of the lesson, and progresses as the student progresses increases its effectiveness." [103]

On the other hand, some teachers highlighted that they aimed student-centered approaches, but they were not successful in general. In this study, they observed that these lesson plans integrating cognitive tools activated students in their learning process as they aimed. One of the teachers shared that he would use these lesson plans as a guide to make his other lessons more active by stating the following:

> "In other words, whether I use any technological tools or not, I think that I will use lesson plan examples in the lesson plan preparation phase from now on and make my plans more active." [104]

Integration of mathematics and daily life

Regarding the effect of integrating cognitive tools on students' learning, integration of mathematics and daily life (*n*=21, *f*=71) is extracted from the interviews. Constructivist learning environments help students see the relation of mathematics with life while focusing on a daily life problem in the lesson plans. Most of the participants agreed that integration of mathematics and daily life motivated students to work on the problems in the lesson plan. One of the teachers highlighted that students saw how they could relate mathematics with daily life by stating the following:

> "They always ask us. What is in it for me? But here, they used mathematics and related technological tools while solving problems from daily life. They saw that it was in daily life." [105]

While teachers emphasized the selection of appropriate problem relating with students' daily lives which makes sense to them, they also suggested to use various examples to make students understand the topic easily and relate the concept with different daily life examples.

Integration of mathematics and technology

Integration of mathematics and technology (*n*=20, *f*=55) is another theme emerged from the interviews The integration of cognitive tools helped students see how they can benefit from mathematics in technology. A sample quote in this regard as follows:

> "I think it opened a new horizon for them as well. It is about the usage areas of mathematics, how we can combine technology and mathematics." [106]

Use of cognitive tools in mathematics lessons were also considered as a guide for students' use of technology effectively. One of the participants stated her opinion as follows:

> "In this period when we are intertwined with technology, I think that using technological tools more actively in the lesson will guide students to use technology correctly." [107]

On the other hand, while students were motivated to integrate technology and mathematics, there were some problems related to readiness. Some students struggled to associate technology with mathematical concepts. This was considered because of two reasons. One of them was ICT readiness. Not knowing the cognitive tool very well affected their association with mathematics. Other one was that they were not used to apply their knowledge in mathematics. One of the teachers suggested the following in this regard:

> “Needed a reminder. Also, it was difficult for them to associate it with mathematics. How will I do, what will I do? What will I use here? They have not encountered anything like this until this lesson. Maybe these parts can be added to the relevant places in the curriculum. Or studies can be done on this starting from primary school, such activities for example. [108]

Collaboration

According to the interviews, the integration of cognitive tools contributed students’ learning by allowing them to work on their projects collaboratively (*n*=12, *f*=38). The teachers indicated that collaborative activities motivated students, contributed their learning and communication between them, especially in emergency remote learning period. A sample quote in this regard as follows:

> “Therefore, I can say that it really contributed to my education. Because one did something, the other contributed to it. It was a very good environment. They produced their projects as a complete teamwork.” [109]

In order to contribute and support each other’s learning in group activities, some teachers suggested that the formation of groups should be considered before implementation. This was also regarded as a solution for problems related to readiness. A participant stated her ideas as follows:

> “In implementation, I saw that it is necessary to pay attention to how these groups are created.” [110]

Developing thinking skills

Teachers mentioned that constructivist learning environments contributed learners in developing thinking skills (*n*=11, *f*=18). The activities designed with cognitive tools helped students discover the relationships without being told them. A teacher indicated her ideas in this regard by saying the following:

> “I think that using technology in this way will have great positive contributions in developing thinking skills and associating.” [111]

Easing task

Another theme extracted from the interviews is the role of cognitive tools as easing task (*n*=4, *f*=9). Teachers mentioned that the cognitive tool should be integrated in a way that it helps students see the complex relationships easily or simplify the task they are doing. A sample quote in this regard is as follows:

> "I make a fiction where the student can see the mathematical relationship more easily while coding. This kid says, "I already do this with pen and paper. Why should I bother?" says. I would like to choose a topic where I will not take this criticism." [112]

Autonomous learners

One of the participants mentioned about the effect of the integration of cognitive tools on students' learning habits (*n*=1, *f*=2). Accordingly, in the long term, students learn how to search the things they are curious about. The integration of cognitive tools teaches them to use technology to solve problems in daily life. This skill helps them to become autonomous learners in the future. A sample quote in this regard is as follows:

> "Individuals who learn the things they are curious about in the long term by researching on their own are raised." [113]

4.4.1.2 Integration of Cognitive Tools

The second theme classified under constructivist learning environments is integration of cognitive tools. The opinions of teachers related to integrating cognitive tools into their lessons were discussed under these categories: Willingness, duration, integrating to yearly plan, determining appropriate objectives, face to face implementation, desire to implement peers' lesson plans, variety of cognitive tools, planning with ICT teachers, desire to share with others, working with different grades, integrating cognitive tools with different subjects, assessment, and designing shorter lesson plans.

Willingness

The interviews indicated that most of the teachers would like to integrate cognitive tools into their mathematics classes (*n*=21, *f*=100) after participating in the online CoP. They agreed on the effect of integrating cognitive on students' learning and indicated willingness to implement the lesson plans they designed during the online CoP and design new lesson plans integrating cognitive tools. One of the participants shared her point of view by stating the following:

> "A long time is devoted to a subject in the curriculum in the mathematics course. I think that I should definitely include such a cognitive tool in at least an hour or two of that long topic." [114]

Increasing duration of lessons

While implementing the lesson plans integrating cognitive tools, teachers observed that they needed more time for implementing such plans in class (*n*=19, *f*=67). They suggested to allocate more time for implementation. A sample quote is as follows:

> "As I said about the implementation, I first consider the time. Because I saw that the lesson we planned for 40 minutes could be implemented much better in two lessons. Implementing it over a wider period of time will be much more effective." [115]

The novelty of designing and implementing lesson plans with cognitive tools was also considered as a reason for not estimating the duration of implementation. One of the teachers stated her opinion in this regard as follows:

> "This was due to the fact that we did not know how much time should be devoted to such a lesson plan." [116]

Integrating to yearly plan

Regarding teachers' experiences of integrating cognitive tools into their classes, they stated that integration of cognitive tools could be more effective by integrating the implementation planning to the yearly plan (*n*=17, *f*=73). Teachers emphasized that these lesson plans should be planned thoroughly considering activities for ICT readiness with ICT teachers. Integrating to yearly plan also gives teachers the flexibility to plan their time and implement it in a wider time period. One of the teachers shared her perspective in this regard as follows:

> "In other words, at the beginning of the year, I should have decided on what kind of work I will do on that subject in general. So, my use of time will also be different. Frankly, it is difficult to include such an event later. Because students need to remember and learn that cognitive tool as well." [117]

Moreover, some of the teachers emphasized that integrating cognitive tools to yearly plans of different grades gave students chance to experience learning with technology. A sample quote in this issue is as follows:

> "And doing it multiple times… Yes, we applied it this year, but next year, sixth graders will be seventh graders again, we can apply something different to grade seven so that something really concrete will emerge. Let the children try to do something with this method." [118]

Determining appropriate cognitive tools

While integrating cognitive tools into mathematics lessons, out of 24, 17 teachers stated that determining appropriate cognitive tools (f=56) for the appropriate objectives was critical. They suggested that reviewing the objectives of the year and identifying appropriate cognitive tools for the selected objectives could help their planning and students' understanding. Since the planning and implementing lesson plans with cognitive tools require much more time, the selection of right tools for the right topics was considered as an important factor. A sample quote in this regard is as follows:

> "In which objective, we can benefit from a cognitive tool that will make it easier for the student to understand and apply what he/she has learned. We need to think about those tools, too. Of course, it may not be possible to

implement in every objective, but I would like to identify the appropriate objectives and apply." T09 – 9

Face to face implementation

Most of the teachers implemented the lesson plans integrating cognitive tools in a remote learning environment because of the pandemic. However, interviews indicated that face to face implementation of the lesson plans with cognitive tools was suggested for future implementations (*n*=17, *f*=39). According to teachers, the remote learning environment limited their support for students during implementation. A teacher emphasized this by stating the following:

> "It would also be better to apply it face-to-face in the computer lab in order to guide the student more easily." [120]

One of the teachers implemented one of the lesson plans in a face-to-face environment at school and shared her observation as follows:

> "For example, we had the chance to apply the Scratch plan face-to-face at school. We immediately saw the feedbacks in face-to-face implementation, and it impressed us even more." [121]

Desire to implement peers' lesson plans

During the online CoP, teachers created two lesson plans integrating cognitive tools within their small groups. Later, they shared the lesson plans and their experiences during the implementations with their peers in the large group. Teachers stated that they could benefit from peers' experiences, and they would like to implement peers' lesson plans in their future plannings (*n*=16, *f*=43). The program provided them variety of lesson plans integrating cognitive tools. A sample quote in this regard is as follows:

> "It was also very useful to see the different examples in the plans prepared by our other friends. In the next year's planning process, I plan to carry the examples that they find effective to my own classes." [122]

Desire to use variety of cognitive tools

Regarding their experiences with two cognitive tools, Excel and Scratch, during the online CoP, teachers emphasized that the program could include more cognitive tools (*n*=9, *f*=27). Interviews indicated that examining variety of cognitive tools could help teachers' knowledge and skill about integrating technology as cognitive tools. A teacher shared her view in this regard as follows:

> "As we see each new tool, I think our perspective broadens. Our comparisons increase." [123]

Planning with ICT teachers

In order to integrate technology as cognitive tools throughout the year, mathematics teachers suggested to work with ICT teachers to identify the possible tools that can be used as a cognitive tool and plan the readiness activities together (*n*=9, *f*=18). Coordinating with ICT teachers was considered as a part of integrating cognitive tools into the yearly plan. A sample quote is as follows:

> "We also need to make plans with the ICT teacher. For example, while teaching Scratch, we can use Scratch as a cognitive tool for a subject that we can use in math class, such as killing two birds with one stone. We can examine the tools that students learn in the ICT course, in this direction, identify the ones that can contribute in the mathematics course, and add cognitive tools in this direction to our programs." [124]

Desire to share with others

Another theme extracted from the interviews is teachers' desire to share what they learned about integrating cognitive tools with other mathematics teachers in their schools (*n*=6, *f*=21). For their future plannings, all mathematics teachers in their schools should be aware of how to integrate cognitive tools. A teacher shared this by stating the following:

> “I plan to share all of them with my own department and benefit from them in the coming semester.” [125]

On the other hand, one of the teachers highlighted that being the only one in school who attended this online CoP about integrating cognitive tools made difficult to apply this approach as a whole department, especially in the departments with a large number of teachers. She shared her point of view as follows:

> “The fact that I am currently the only one in the department to attend this training and to have received this training is very difficult to disseminate in terms of practices at school. This is a negative aspect from my point of view. Maybe it would be easier for smaller departments to share and disseminate it with their department friends.” [126]

Working with different grades

Regarding teachers’ experiences of integrating cognitive tools with sixth graders during the online CoP, teachers emphasized that the program could include activities for different grades (*n*=5, *f*=13). Working with different grades through the online CoP was considered as an enrichment for learning how to integrate cognitive tools. A teacher suggested this by stating the following:

> “Actually, maybe we applied it to the 6th grades, maybe it would have been different if it had been done to all levels? Did it provide more examples for us, too? Yes, we chose different achievements of the 6th grade, but maybe it can be diversified as 5th, 6th, 7th. Maybe it was possible to see how something would come out in high school groups?” [127]

Integrating cognitive tools to different subjects

Interviews indicated that teachers considered cognitive tools as tools which can be associated with different subjects (*n*=5, *f*=11). This association was made in terms of both different disciplines such as social sciences and different topics in mathematics.

Regarding multidisciplinary studies, teachers emphasized the role of ICT course for other disciplines. Each discipline can benefit from cognitive tools to help students' understanding. A teacher shared her view in integrating cognitive tools to different disciplines by stating the following:

> "I think it should be spread across disciplines. That's why I think it should be integrated throughout the school. I think that the ICT course should be adapted to social studies, even to Turkish." [128]

On the other hand, another teacher explained that learning how to integrate cognitive tools in one objective could help adapt the same approach for other objectives in mathematics. A sample quote of hers is as follows:

> "There is one thing though, once you have learned the activity, you can adapt it to apply it to different objectives. For example, I always remember that I also teach the 5th grades, but there are a lot of things that I say I can use there as well. [129]

Assessment

Based on the experience of designing a lesson plan with cognitive tools, one of the teachers stated that the assessment parts of the lesson plans were not adequate (n=1, f=11). Accordingly, she suggested to work on the assessment parts of these lesson plans and assess students' understanding with their products, homework rather than problems as they used in a traditional class by stating the following:

> "However, sample questions to the questions we used while teaching the subject were mostly included in the evaluation part. Maybe because it doesn't suit my style. Did you learn at that moment? Okay. For example, we came to the end of the lesson, we could have given one product. We could assign homework and evaluate that homework. I would like to keep the assessment part wider in both sample lesson plans." [130]

Designing shorter lesson plans

Regarding the experience of examining sample lesson plans and designing lesson plans integrating cognitive tools, one of the participants stated that the lesson plans could be briefer (*n*=1, *f*=2). Although she considered these detailed lesson plans as a part of the training, she stated that she preferred to design shorter lesson plans in integrating cognitive tools.

4.4.1.3 Challenges of integrating cognitive tools

The third theme classified under constructivist learning environments is challenges of integrating cognitive tools. The interviews indicated what challenges were considered by teachers in integrating cognitive tools. These are teachers' competencies, online implementation, extra time for planning, curriculum, preparing students to the exam, limited ICT lesson duration, and workload of ICT teachers.

Teachers' competencies

Considering the challenges of integrating cognitive tools, teachers mentioned that their competencies could be a challenge (*n*=21, *f*=70). Teachers' competencies were examined in two categories. One was related to teachers' ICT competencies while the other one was related to teachers' competencies about the technology integration method, which is constructivist learning environments.

Teachers stated that their ICT competencies were critical to integrate a cognitive tool. Accordingly, when they have adequate knowledge and skills about the tool, they could design effective lesson plans integrating that tool as a cognitive tool. A teacher shared her opinion in designing a lesson plan with a cognitive tool that she knows as follows:

> "After knowing and researching that program, I think I can be more creative in the planning and idea stage about how I can do it. I think I can find more applicable things." [245]

As well as the effect of teachers' ICT competencies on designing creative lesson plans, teachers also mentioned the effect on their allocated time for integrating cognitive tools. Findings indicated that when teachers did not know the tool, they needed to allocate time for learning the tool first. After this part, they could design and implement a lesson plan integrating that tool. So, it became a challenge. One of the teachers shared her comparison of Scratch and Excel in this regard as follows:

> "But if I'm going to make them write a program, I have to write it first. I need to have a good command of Scratch. I have to devote a lot of time to this. Naturally, I prefer more practical applications. Excel was easier for us in this sense." [246]

On the other hand, another teacher competency that has an effect on integration of cognitive tools is knowing constructivist learning environment. In order to integrate technology as a cognitive tool that students use by themselves to create artifacts while they are learning, teachers needed to learn the principles of constructivist learning environments. By participating in the online CoP, teachers stated that they started to consider tools they know as cognitive tools in mathematics and how they could benefit from them. In this regard, one of the participants stated her point of view as follows:

> "The training program made it easy for us to associate programs we know with mathematics, such as Excel and Scratch." [247]

Similarly, another teacher highlighted the effect of trying a new approach in integrating technology as follows:

> "I was feeling very inadequate in this regard, and concerns such as how it would be and whether we could do it were very intense." [248]

Online implementation

While experiencing the implementation of lesson plans integrating cognitive tools, emergency remote learning period was also considered as a challenge (n=19, f=62). Teachers mentioned that they had struggles in terms of classroom management, students' connection through mobile tools, the limited lesson durations while implementing lesson plans in online environment.

A sample quote related to classroom management problems during online implementation is stated as follows:

> "Of course, the school environment is very different in terms of classroom management. You know, no matter we follow students with cameras, sometimes things can happen in the background that we don't know." [249]

Another challenge that teachers encountered during online implementation was students' connection through mobile tools which affected their participation in activities based on Scratch and Excel. A teacher stated her opinion in this regard as follows:

> "We made pairs, but some of them, for example, did not have a program on the computer. Those students had a bit of a hard time in those first weeks when they had to participate from their tablet or phone. The other one was a bit more like a leader. So yes, they helped each other, but one of them fell little behind." [250]

According to findings, teachers needed more time for implementing the lesson plans integrating cognitive tools. So, the limited lesson duration in online implementation was considered as a problem for integrating cognitive tools. In this regard, a participant shared her experience by stating the following:

> "When it is online, the lesson durations have shortened a bit, and there is a pressure created by it." [251]

Extra time for planning

During the online CoP, teachers experienced the design process and the planning of implementation of lesson plans integrating cognitive tools. According to findings, this process of design and planning required extra time which was considered as a challenge in integrating cognitive tools (n=18, f=56).

While designing a lesson plan integrating cognitive tools, the extensive consideration of the topic and appropriate tool was required unlike any other lesson plan teachers did. A teacher highlighted the significance of a detailed lesson planning in integrating cognitive tools by stating the following:

> "This part of creating the plan is actually maybe eighty percent of the job, I realized that it is very important to plan ahead." [252]

Furthermore, teachers mentioned the extra time for planning the implementation. A sample quote in this regard as follows:

> "But things like preparation, working with the ICT teacher, planning for readiness are also things that take a lot of time and effort." [253]

Curriculum

While integrating cognitive tools into mathematics lessons, another challenge extracted from interviews is the intensiveness of the curriculum (*n*=12, *f*=57). Half of the teachers stated that the curriculum did not allow them to allocate time for constructivist learning environments which require more time to implement. The intensive content load made teachers focus on the fastest ways of teaching although they agreed on the positive effect of integrating cognitive tools in mathematics learning. A sample quote states this issue as follows:

> "I agree with this a lot, but in a sense, there is a progressing curriculum. The curriculum is incompatible with this point of view." [254]

In addition, emergency remote learning period also affected the pace of learning. Teachers tried to cover curriculum topics, which is already intensive, in a remote environment, and it required more time even in traditional approaches. Hence, placing a lesson plan integrating cognitive tools in such a tight program became a challenge in terms of curriculum. One of the teachers stated her situation in this issue with the following quote:

> "On the other hand, I was behind in the curriculum due to the pandemic." [255]

Preparing students to the national exams

As well as the intensive curriculum, preparing students to the national exams (*n*=8, *f*=35) was considered as a challenge in the integration of technology as cognitive tools by teachers. According to findings, teachers did not think of the integration of cognitive tools for the eighth grades considering the exam pressure since these lesson plans integrating cognitive tools required more time and decreased the time for worked examples for that topic. The pressure of being successful at exams was made by both parents and schools. Hence, they stated that this perspective would limit their technology integration studies. A teacher shared her opinion in this issue as follows:

> "So, this pressure leads me to this. Instead of doing such activities, there are moments when I say that I will solve this question right here. Believe me, it does. Because there is tremendous pressure on us at that point, from both parents and school. This is my unchanged opinion, that is, to focus only on problem solving due to system pressure…" [256]

Limited ICT lesson duration

Limited ICT lesson duration (*n*=3, *f*=19) was extracted from the interviews as another challenge for integrating technology as cognitive tools. During their experience of the online CoP, ICT readiness of students and planning of activities related to increase students' ICT readiness were affected by this limitation. In order to integrate cognitive tools with an interdisciplinary approach, they suggested to increase ICT lesson duration.

On the other hand, one of the teachers explained the removal of ICT lessons from the program during the emergency remote learning period in her school context and its effects by stating the following:

> "But I can say as a negative side in terms of students that the weekly lesson hours of ICT are not many, and during the pandemic process, we first place

> the main courses in the program as a school. For this reason, I think that this is one of the biggest reasons why we have difficulties in students' readiness in this sense. [257]

Workload of ICT teachers

Integration of technology as cognitive tools required a collaborative approach with ICT teachers during lesson planning, doing preparations for ICT readiness, learning the cognitive tool, and implementing the lesson plan. According to interviews, teachers found this collaboration difficult because of workload of ICT teachers (*n*=2, *f*=7), in turn, it would affect integration of cognitive tools negatively. One of the teachers stated her opinion in this regard as follows:

> "Most of the time I can't see our ICT teacher. He's very busy, he teaches all levels. Therefore, it is very difficult for us to meet." [258]

4.4.1.4 Readiness of Students

The fourth theme classified under constructivist learning environments is readiness of students. This theme was analyzed through two categories: ICT readiness and mathematics readiness.

ICT Readiness

Findings indicated that ICT readiness in constructivist learning environments was significant while integrating cognitive tools (*n*=23, *f*=145). Almost all teachers highlighted that students' ICT readiness had an effect on their understanding mathematics by using the cognitive tool. Hence, while integrating cognitive tools, students' ICT readiness was suggested to be a consideration. One of the teachers stated this issue as follows:

> "First of all, the readiness of the children… For example, the reason why we applied it so easily was that the child's prior knowledge was strong. This is both mathematical knowledge and programming knowledge. For example, it

would be much more difficult for a child who does not know Scratch to apply it." [131]

On the other hand, teachers mentioned that ICT readiness activities for students should be planned with ICT teachers carefully because they encountered some problems during their implementation related to students' readiness for the cognitive tool. During emergency remote learning period, the ICT lessons were removed from students' programs, this also affected negatively students' readiness in ICT according to the interviews. A sample quote in this regard is as follows:

"For this reason, it is very critical for children to know the tool we use well. For this reason, we have determined that the first thing we will do next year is to start with a more intense reminder process to adjust the levels of students. We had planned this again this year, but the fact that they were in online environment had a negative impact. For example, we didn't have ICT lessons for 5th and 6th graders this year... So, it coincided with a slightly worse period for them." [131]

Mathematics Readiness

As well as ICT readiness, teachers highlighted that students' prior knowledge in mathematics was also critical in using cognitive tools to learn something new (*n*=10, *f*=25). Their mathematics readiness was considered as an enabler in their participation in collaborative activities and their own learning process within a constructivist learning environment. One of the participants shared her opinion in this regard as follows:

"When we did it with our team, we reminded what is the coefficient, four operations, we reminded the operation priority. Of course, prior knowledge is required. Of course, I think it is necessary to have prior knowledge in order to be able to understand or comment or feel as a part of teamwork." [132]

4.4.1.5 Teachers' Role in Constructivist Learning Environments

The fifth theme classified under constructivist learning environments is teachers' role in constructivist learning environments. Findings in this theme were reported in three categories: support for students, facilitation, and classroom management.

Support for Students

Interviews indicated that teachers provided necessary support for students whenever they needed while working on the problems with a cognitive tool in terms of both ICT and mathematics (n=14, f=45). While integrating cognitive tools, they considered support mechanisms as essential. During implementation, ICT teachers also participated in the lesson in order to provide necessary support in terms of ICT. One of the teachers explained their roles in constructivist learning environments by stating the following:

> "Even in the online environment, we provided support to the students by visiting their breakout rooms with the ICT teacher separately. As a mathematics teacher, I mostly provided support for them to establish the mathematical relationship there. What are we doing, why are we doing it?" [133]

On the other hand, implementing the lesson plans remotely was limited teachers' support for students. According to teachers, implementing them face to face would give them more chances to help them understand and move forward in their projects. A teacher shared her opinion in this regard as follows:

> "Up to a certain point, for example, the child says I don't understand, I don't know Scratch. But if we were with him, I would have told him by showing him in the computer environment." [134]

Facilitation

According to findings, constructivist learning environments positioned teachers as a facilitator in students' learning (n=12, f=37). During the implementation of the lesson plans integrating cognitive tools, teachers took a role of a guide which let students think, discover, and apply, and provide guidance when it is needed. They stated that they experienced being more passive in the lesson and being supportive by asking the right questions that help students understanding and providing required hints in constructivist learning environments.

One of the participants highlighted the effect of lesson plans including a problem that students work on the facilitator role of teachers by stating the following:

> "In other words, you, as a teacher, are preparing such an activity plan that you only guide the student after giving that problem. I think this is something that has always been aimed… For the student to be active… Therefore, integrating technology as a cognitive tool has exemplified this for us." [135]

Classroom Management

Constructivist learning environments also affected teachers' roles in terms of classroom management (*n*=2, *f*=5). Some teachers highlighted that the classroom atmosphere, the characteristics of students, and their perception of technology integration caused classroom management problems while implementing the lesson plans integrating cognitive tools. A sample quote in this regard is as follows:

> "So, the downside is that it is a little more difficult for me manage the class. The child was approaching as if we were playing games when there was no pen and paper. It was a little more difficult for me to attract their attention to the lesson. The same is true in face-to-face education." [136]

4.4.1.6 Change in Students' Attitudes

The sixth theme classified under constructivist learning environments is change in students' attitudes. In this theme, students' attitudes towards ICT and mathematics were reported based on the interviews.

Students' Attitudes Towards ICT

According to the interviews, students' attitudes towards ICT was critical in constructivist learning environments (*n*=11, *f*=20). Most of the teachers highlighted that students' positive attitudes of towards ICT affected their participation and motivation in constructivist learning environments. A sample quote in this regard is as follows:

> "We were really able to keep the attention of successful student in the process. Academically lower-level students also say there is an activity, there is something. And these children are the generation z, that is, maybe they are much more prone to technological tools than we are. Their interest has increased. In other words, I felt that I could keep both successful and unsuccessful students active in these implementations and I was really happy. Both my top-level student and my lower-level student were always active throughout the process." [137]

On the other hand, one of the teachers mentioned that there were students who associated technology with playing games and could not understand the role of cognitive tools in learning mathematics. She thought that this was because they were not familiar with constructivist learning environments in mathematics lessons by stating the following:

> "In other words, when a computer-related program is included in the mathematics lesson, it is as if they are playing a game… They think as if they are not doing such a temporary, important thing. Because they didn't use it fully, because they didn't see it as a part of the normal lesson, the children had that feeling." [138]

As well as positive attitudes towards ICT, the findings indicated that students' negative attitudes towards ICT was also important in constructivist learning environments. Accordingly, students may not have any interest in ICT or may have bias related to their own ICT abilities. One the teachers mentioned this issue regarding Scratch as a cognitive tool by stating the following:

> "For the student who is not interested in coding, it is much more difficult to both try to understand the coding and see the mathematical association." [139]

Students' Attitudes Towards Mathematics

Findings showed that teachers highlighted the role of constructivist learning environments in students' attitudes towards mathematics (*n*=6, *f*=16). Accordingly, mathematics was a course which most students were afraid of and did not like, and constructivist learning environments gave students chances to experience different mathematics lesson in which they could create a product through cognitive tools, participate actively, and get motivated by the work they did. This was considered as a chance to change their attitudes towards mathematics. A sample quote in this regard is as follows:

> "Yes, we can produce something with this computer, we give it to them. Interdisciplinary approach goes together, and this breaks their prejudices when I talk on the basis of mathematics. Mathematics is not a scary and boring subject. Because fun can be added to it. It can be associated with daily life." [140]

4.4.2 Maintaining Online CoP

The opinions of the teachers about maintaining online CoP were analyzed as a guide for the instructional design of teacher professional development programs on technology integration. The results of these analyses have been reported in four themes: participation of teachers, interaction between teachers, functioning of roles, and suggestions related to online CoP. The categories under each theme, the number of participants stated the relevant category, and the frequency of statements are given in Table 4.4.2.

Table 4.4.2 Maintaining Online CoP

Themes	Categories	Number of participants (*n*)	Frequency (*f*)
Participation of teachers	Workload of teachers	22	70
	Active participation of teachers	22	51
	Changes in motivation	18	53
	Instability because of pandemic	17	45
	Time during working hours	16	50
	Willingness to attend similar online CoP	7	11
	Delegating the duties	5	38
	Face-to-face participation to CoP	5	13
Interaction between teachers	Interaction	24	143
	Communication	16	96
	ICT related issues	6	28
	Novelty	5	10
Functioning of roles	Distribution of the roles	21	56
	Performing the roles	18	101
	Roles to maintain online CoP	17	45
	Extra time for the roles	9	27
	Orientation	7	18
	Switching roles through activities	5	14
Suggestions related to online CoP	Working with different grades	5	13
	Collaborating with an academician	1	10
	Peer observations	1	4
	Adding some time between planning and implementing	1	4
	Working with only one small group	1	2
	Attending two teachers from the same school	1	1

Total number of participants: 24

4.4.2.1 Participation of teachers

The first theme classified under maintaining online CoP is participation of teachers. The considerations of teachers related to what is critical for their participation were extracted from their responses as workload of teachers, motivation, active participation of teachers, time during working hours, instability because of pandemic, delegating duties, face-to-face participation to CoP, and willingness to attend similar online CoP.

Workload of teachers

Teachers highlight the effect of their workload on their participation to online CoP (*n*=22, *f*=70). According to their responses, they had busy schedules including high number of lessons, extra tasks within school, other tasks related to emergency remote learning. The workload of teachers affected teachers' participation to online CoP.

The high number of lessons teachers had limited teachers' concentration on their professional development activities. Most of the teachers emphasized their heavy workload during the semester. Some teachers explained the delays in participation of activities and missing deadlines as a result of concentrating on various tasks. A teacher, for instance, explained below her situation in this regard:

> "I may have missed a bit because sometimes I get distracted when I concentrate on more than one thing. Ok, there were some problems there, other than that, I tried to follow, I tried to participate in every activity you gave. But of course, I am not sure if there were things I missed. … It would be much better if we could concentrate better." [141]

Extra tasks such as taking role in the assessment committee and planning extra study times with students also influenced the participation. One of the teachers stated her ideas on this as follows:

> "Things such as the school process, the changes brought by the pandemic, the anxiety of managing the curriculum may have caused us not to follow the program well. This situation hindered me at some points. When I felt that pressure, I gave priority to other works, even though I didn't want to." [142]

Teachers also mentioned that the emergent remote education period brings extra workload for teachers. They highlight the extraordinary situation that they had lived and the extra tasks that they had done such as adapting their lesson plans to the remote education. The previous quotation also indicates the various factors that created pressure on teachers.

Active participation of teachers

Out of 24, 22 teachers point out that the activities allow them to participate actively in the teacher professional development program (*f*=51). They worked on examining sample lesson plans, preparing a lesson plan collaboratively, implementing it in the classroom, and sharing their opinions. Teachers compared their previous professional development activities and stated as follows:

> "But other than that, I think it contributed much more than other trainings I've had, listening to a seminar or watching what someone is doing. Because it requires one-on-one participation." [143]

Most of the teachers expressed that they had participated actively in the activities. However, some activities had lasted longer because teachers couldn't participate timely. One teacher self-criticized by saying the following:

> "Not very well obviously. I can criticize myself about this. I could have been a little more active." [144]

Moreover, teachers' interest and motivation are stated as critical for active participation. The following quote indicates how teachers' interest and motivation affected their active participation.

> "But since I have a curiosity about it, I have always been involved." [145]

Changes in Motivation

Teachers point out that their motivation is also critical for their participation (*n*=18, *f*=53). The pandemic affected teachers' motivation to participate actively. One teacher highlighted the increased screen time. Sample quote mentioning the changes in teachers' motivation during the pandemic is as follows:

> "In other words, our motivation has had its ups and downs from time to time due to the uncertainty of the process. We always talk about students, but I say, what about us, teachers?" [146]

While some of them stated that teachers' interest is critical for participation, one of them expressed that the level of interest in CoP can vary. An example quote is as follows:

> "Their own motivations for the study may have influenced participation. Those who were really interested in the subject were sharing little more detailed comments." [147]

Teachers' observations related to learners' motivation and participation in CLEs influenced their participation in online CoP positively. A sample statement related to this issue are as follows:

> "Therefore, we, as teachers, are more motivated in order to share their excitement in the lesson, in trainings where we will learn such technology integration." [148]

One of the teachers mentioned the importance of recognition by school administration. The extra effort that teachers made for their professional development should be recognized both during the professional development program and at the end of it. Her statement is as follows:

> "In addition, school administrations need to follow what is done in this process, what tasks teachers take on what steps. My school principal also asked me questions about the process, and when I reached the final stage, I received a thank you e-mail. Obviously, that was a source of motivation." [149]

Instability because of pandemic

Most of the teachers stated that their participation was affected by the instability because of pandemic (n=17, f=45). The change in current state and implementations required them to adapt to every change. They could not focus on their professional development program while both school and home life were changing. A sample statement related to this issue is as follows:

> “This situation, of course, was affected by the pandemic process. There was constant change. We worked from a house for a while, then we went back to school. Our lesson hours were 30 minutes for a while, then it increased to 40 minutes. We planned extra studying classes. Home life after school was also in perpetual chaos. For example, we are at school right now, that process has recovered a little more. But while we were maintaining these activities, it was a really bad time for us.” [150]

Time during working hours

Time during working hours is highlighted in the interviews regarding its effect on the participation (*n*=16, *f*=50). Most of the teachers stated that they had problems to find time for participation in online CoP. Schools did not allocate time for teachers to attend teacher professional development programs in working hours and they had to use their own time for active participation. A sample statement related to this issue is as follows:

> “It would have been more productive if it had been done during the seminar period. Because the teacher has to plan the participation in education by taking his own time.” [151]

On the other hand, a teacher mentioned her situation that she had time for participation. In turn, she easily participated in online CoP for her professional development by saying the following:

> “When I think of myself as a participant, I don't have a heavy workload this year, so frankly, I don't have many classes this year. That's why I had some time to prepare for TÜBİTAK or do something. So, it wasn't a big problem for me to participate.” [152]

Willingness to attend similar online CoP

Interviews revealed teachers’ opinions about participating in online CoPs for their professional development on technology integration. They expressed their willingness to attend similar online CoP for their professional development (*n*=7, *f*=11). An example quote is as follows:

> "As I said, I would like to participate again because I really enjoyed it. Because it has given me a lot." [153]

On the other hand, one teacher emphasized the workload caused by pandemic and the extra time requirement of participation would prevent him to participate in such an online CoP in the short term by saying the following:

> "Maybe if something is done in the long term, I will participate, but in the short term, I do not want to participate with such a heavy workload. Because it takes a lot of extra time." [154]

Delegating the duties

One of the things that affected participation is specified as delegating the duties (*n*=5, *f*=38). Although there are roles to maintain online CoP such as leader, reporter, and timekeeper, teachers mentioned that the task should have been divided into parts and the duties should have been delegated to the participants. According to their statements, the delegation of the duties helps participants take their role actively and contribute to the activity. Especially, they suggested that lesson planning activities should be given into parts and assigned to specific people within the group. Then they can combine all the parts and share their opinions while finalizing. Teachers emphasized that this would accelerate the process and ensure everyone's participation. An example statement in this issue is stated as follows:

> "We would say to someone 'You do the introduction part'. We could give the development part to one another, and the evaluation part to another. It could have gone better that way. We could have divided this lesson plan development work into sections and brought it together." [155]

Face-to-face participation to CoP

Regarding participation, another suggestion that emerged from the interviews is face-to-face participation to CoP (*n*=5, *f*=13). Teachers expressed that face-to-face participation may contribute to their active participation by stating the following quotes:

> "There, of course, our interaction is much higher. You are face to face. You are together for 3 days and you are producing a common product." [156]

4.4.2.2 Interaction between teachers

The second theme classified under maintaining online CoP is interaction between teachers. The considerations of teachers related to what is critical for this theme were extracted from their responses as interaction, communication, ICT related issues, and novelty.

Interaction

Teachers mentioned their opinions about interaction through the online CoP (*n*=24, *f*=143). In this category, two codes emerged; interaction quality and interaction quantity.

For interaction quality, most of the teachers emphasized the role of positive environment. The rapport between group members, the motivations and experiences of members were stated as significant factors that affected interaction quality.

> "I was comfortable making suggestions, I think that positive atmosphere was very important, in terms of encouraging creativity." [157]

Some of the teachers found the interaction quality as good enough whereas some others considered that it could be better. They claim that there could have been more details in their comments. One of the teachers stated her hesitation in that issue as follows:

> “Yes, there weren't many details, frankly. I can even say this. Sometimes I wrote at length. Then I looked, so I said I guess I'm taking too long. I often cut off sentences by looking at the posts of our other teachers.” [158]

Moreover, the lack of details in some comments was associated with the teachers’ similar opinions and experiences. Some teachers stated that this could be a personal choice not to repeat same issues. Some others highlighted the workload they had influenced their interaction quality.

On the other hand, the interviews indicated that the quality interaction of teachers about lesson plans and implementations contributed to them. A teacher stated her opinion in this issue as follows:

> “I think the interactions were good overall. They showed us all different points of view. There weren't any situations where I felt like it was made to do it. Everyone tried to write as best they could. They always added something. What I read was not like that. There were always points that I said they thought like that. In fact, when I look at whom I agree with or disagree with, I take a note for myself … It was a phrase I had designed in my head but could not put into words. Overall, there was good interaction both in terms of quantity and quality.” [159]

More than half of the participants considered that the interaction quantity could have been better. It was associated with workload and lack of time allocated for participation during working hours. On the other hand, one teacher emphasized the change in interaction throughout the activities by stating the following quote:

> “In other words, after applying it, I think since it attracts their attention... If you noticed that there wasn't much participation at first, but then it started to increase. I think that the more people are interested in it, the more the participation increases.” [160]

The lack of interaction quantity was also stated as a negative factor for the participation. It was described as follows:

> “Of course, sometimes no sound from the group can cause you to drift away from the subject.” T14 – 49

Some teachers suggested to delegate tasks within group members, then combine each part and discuss on this combined lesson plan in order to increase the quantity of interaction. Making responsible each participant for doing a specific task was considered as an intensifier for the quantity.

Communication

Considering interaction between teachers, another emerged category from the interviews is communication (*n*=16, *f*=96).

While participating in the online CoP, scheduling routine online meetings was suggested as a communication way. Some teachers proposed these meetings for lesson planning activities whereas some offered them for activities related to learning the cognitive tool. Most of them highlighted that routine meetings would increase the quality of interaction. In this regard, one teacher shared her perspective as follows:

> “We can routinize. We can be more careful with the timeframe. For example, a process evaluation can be done every two weeks. What have we done, what are we doing, where are we? The routine always progresses healthier. In other words, if people know that there will be a meeting two weeks in advance, they make their preparations accordingly. He says we will talk today. He implements something that he has not implemented. He will be more prepared.” [162]

Regarding communication, while one teacher emphasized the advantage of asynchronous communication as not interrupting their daily schedule and participating based on their availability, some teachers mentioned the difficulties that they faced while communicating asynchronously through a discussion board. There were delays in participating in discussions. A sample quotation related to this issue as follows:

> “It is very difficult to follow and finalize them over the platform by correspondence… In fact, it is more effective when the process takes a shorter time, not because it takes a shorter time. Because the longer it takes, the further you move away from the goal you want to reach because you start to exaggerate the activity at first. Interest may also decrease.” [163]

Another difficulty extracted from interviews is based on feeling isolated. One teacher stated that she felt this way at some point because of the online environment. The asynchronous communication affected the interaction quality and quantity since the participants had not known each other.

Moreover, some teachers suggested that the communication between groups could be increased. A sample quotation states the following:

> “Especially the last meeting was very enjoyable. I wondered if it would be a little more motivating if we gathered after each activity. Because it was nice to see friends from other schools and to see their work. It was also important in terms of getting ideas or looking at our own group.” [164]

The other point remarked in the interviews is informing participants about the activities. Although the activities were shared on the learning management system by the moderator, one teacher highlighted that WhatsApp group helped them a lot to follow the activities since it was a more common way of communication. The moderator announced the activities on the WhatsApp group as well as the learning management system.

ICT related issues

Out of 24, 5 teachers highlight the effect of ICT related issues (*f*=28) on their interaction during online CoP. Some teachers stated the need of notifications from the learning management and a mobile application. A sample quote is as follows:

> “Maybe I didn't receive many notifications from this platform, frankly. Maybe it would be good to make it a notification, you know when a comment is made, you know it happens or it gives you notifications like this, it would

> be good to receive notifications such as commented, liked. If it was a little more mobile, maybe we would be much more comfortable. This notice was needed, which made tracking difficult. You know, I always reminded myself from time to time, let's see during the day, is there anything I should follow?" [165]

While some teachers stated that the learning management system would be more useful to follow the discussions, one teacher considered that they used both the platform and the WhatsApp group based on their needs. The platform was used for discussions and the WhatsApp group was used for announcements and reminders.

Moreover, one teacher emphasized the technical problem that she faced while participating in discussions as follows:

> "Was it a little difficult to log in our current teaching management system and enter our own study area in the social groups section? Once I couldn't save what I wrote. That's why I used to save what I was going to write in the notes section, then copy it from there and add to the system. Is this glitch I'm experiencing making people's jobs harder? I was wondering if anyone has experienced this like me. I think that this can negatively affect the interaction." [166]

Novelty

Another category emerged from the interviews regarding interaction between teachers is novelty (*n*=5, *f*=10). The interviews indicated three sub-themes in this topic: the novelty of online CoP, the novelty of participants, the novelty of cognitive tools.

One of the teachers shared her hesitation in the novelty of online CoP by stating the following:

> "Also, because I attended such a training for the first time, I couldn't make up my mind about what to do." [167]

Regarding the novelty of participants, one teacher stated that it could be a disadvantage in terms of interaction but since the program was maintained online, it was not big deal. On the other hand, another teacher stated her opinion in this issue as follows:

> "Of course, the fact that we are from different schools, and we do not know each other also caused people to hesitate. Maybe if we were in the same school, we could have done something more collaboratively and easily." [168]

One participant explained his perspective in terms of the novelty of the cognitive tools used in online CoP as follows:

> "Not knowing these tools, especially Scratch… So, when we hear its name, I wonder if we can do it? So, what should we do? This thought may have slowed us down a bit." [169]

4.4.2.3 The functioning of roles

The third theme classified under maintaining online CoP is the functioning of roles. The considerations of teachers related to roles were extracted from their responses as the distribution of roles, performing the roles, roles to maintain online CoP, extra time for the roles, orientation, and switching roles through activities.

The distribution of the roles

Teachers mentioned their opinions about the distribution of the roles that help maintain the online CoP (n=21, f=56). Majority of participants stated that the roles were distributed on a voluntary basis, and it was democratic and fair. According to the interviews, each participant considered his/her availability and characteristics while taking roles.

On the other hand, some teachers stated that they felt anxious to take roles to maintain online CoP. Their hesitations were related to their experience, the novelty of online CoP, and the instability because of pandemic. One of them explained her opinions in this issue as follows:

> "This year is also my first year at this school, I was in the mood to not to be involved. Frankly, I never dared. I also thought that they would be much more useful since there are much more experienced teachers in the institution and there are teachers who have been working for years. Maybe because I also thought they could do it in a much better way." [170]

Some participants also stated lack of volunteering during distribution of roles within their group. One of them explained that since there were limited roles, everyone wanted to take responsibility of just being a participant. It made volunteering difficult. A sample quote is as follows:

> "If everyone had a role, it wouldn't be a problem. When someone was left as just a participant, this time it was wanted to take that responsibility only. It would be better if we assign roles to each participant. When everyone felt they had to take charge, they would." [171]

Apart from these, two teachers suggested that there is no need to distribute the roles. One of them shared her opinions as follows:

> "I thought, maybe there is no need to do the distribution of roles, because in the process, I felt like everyone was taking on their roles by themselves. For example, I remember asking the question in more groups. What stage are we at right now? I had become something of a timekeeper." [172]

Performing the roles

Teachers expressed their opinions about performing the roles. (*n*=18, *f*=101). The difficulties they faced during performing the roles and other group members' opinions related to the roles were described.

It is stated that the roles were performed better in the first activities. However, because of the pandemic and teachers' workload, there were delays in the planned activities. The roles were affected by the changing deadlines. A sample quotation in this issue from a timekeeper is as follows:

> "But at some point, we all broke down because we couldn't keep up. While I myself had difficulties in doing the activities on time, I was hesitant about writing a reminder to the group. I thought I should complete that activity myself first, to remind everyone." [173]

Another hesitation related to performing roles is reminding others what to do through writing. One participant who took the timekeeper role in her group shared her hesitation by stating the following:

> "Even while I was saying it, I had some concerns about how I wrote it, went over it, and whether I should put this or that in the sentence. So that no one would misunderstand, so that I wouldn't feel like giving orders… The coldness of the written language also affected it." [174]

According to the interviews, teachers who took timekeeper, leader, and reporter roles gained extra experience in managing an online CoP through performing roles. Moreover, the significance of appropriateness of the role to the personal characteristics was also highlighted regarding performing roles.

Regarding the level of performance, it is stated that roles were not performed as it was supposed to do. A teacher who took the leader role evaluated her performance as follows:

> "I took on the role of the leader, but because of the effects such as the general workload of our teachers, their unwillingness, etc., I don't think I performed the role effectively. As a pioneer, I had to share and encourage my friends in the group." [175]

Moreover, a reporter specified that she realized the significance of her role within the group at the end of the online CoP. A participant also described that the reporter could make more frequent summaries throughout the discussions.

On the other hand, the interviews indicated that the support from the moderator helped maintain the online CoP. The moderator reminded the remaining time, followed the posts, and invited others to share when needed. One teacher emphasized the support from the moderator with the following quote:

> "You were the one who brought us together. But I think it was important that it was done by you again. Because any of my friends might not have been able to carry out that task... But I think there is a great need for this kind of moderator role in such events." T19 – 45

Roles to maintain online CoP

The interviews indicated what the participants think about the defined roles and new roles to be defined to maintain online CoP (n=17, f=45).

The defined roles which are leader, timekeeper and reporter were considered as required and enough to maintain online CoP by many of them. A teacher shared her thought as follows:

> "After the team is formed, I think the roles are sufficient. The important thing is to act with that sense of doing something together and achieving." [176]

On the other hand, additional roles were suggested. Since the schedule of each school differs, the implementation time of the same lesson plan was different. This affected the flow of the program. One suggested role was related to organize the implementation time of the lesson plans across schools. The teacher also highlighted that this need could be related to the pandemic because schools had struggles to follow the curriculum as it was planned.

Another suggestion was having a role model who planned and implemented lesson plans with cognitive tools earlier. A sample quote in this issue as follows:

> "For example, I don't know what that name would be, but someone who has a good command of the program we will implement could have done an individual study with the teachers. It's like I'm also a student, that teacher, for

> example, is teaching a program to me by exploring together. Maybe something like this could happen.” [177]

Moreover, ICT teachers were suggested to be given a role to maintain online CoP. For instance, from defined roles, timekeeper role was suggested to assign to one of the ICT teachers within the group to make them more involved in online CoP. A teacher offered a new role for ICT teachers as reminding the group students’ capabilities during lesson planning by stating the following:

> “As I said, a role as an ICT teacher could share this with us. Thus, we could better understand what the 6th grade students know or do not know about Excel, for example. We could move in that direction.” [178]

One of the teachers emphasized the significance of leader role and its workload. She suggested that this role could be assigned to two participants. Also, she proposed a role for communication. This role could recall and encourage the participants to discuss the relevant task. As well as these roles, a controller was suggested to check the reporter’s summary as a second eye.

Extra time for the roles

While participating in the activities, taking the responsibility of another role such as leader, timekeeper, or reporter required extra time according to the interviews (n=9, f=27). A participant who took the timekeeper role within the group shared her ideas as follows:

> “In addition, a constant follow-up was required in the role of timekeeper in the process. Even if you complete your own review during the day or that week, it is necessary to check the groupmates. It is very difficult to allocate time for this in school.” [179]

Extra time for checking every member’s participation was also described as a result of the delays in participating.

Similarly, another participant who took the reporter role highlighted the unequal workload within the group by stating the following:

> "So, if such a study is done again, maybe this can be done. Everyone can have a role in the group. Because there were friends who weren't there or couldn't spare time for it as much as we did." [180]

The same participant also mentioned that those roles benefited from the activities more than others because they spent extra time within the activities while summarizing. So, this chance should be provided to every group member.

On the other hand, one teacher stated that since the teachers' workload was high, they were not interested in taking responsibility of these roles at the beginning considering the extra workload of these roles.

Orientation

The interviews indicated teachers' opinions about orientation of the roles (n=7, f=18). The orientation period affected both the processes of choosing and performing the roles.

One of the participants explained her ideas about how orientation about the roles affected her volunteering in the process of distribution of roles by stating the following:

> "In fact, at the beginning, I did not know what kind of task awaits us, as I did not know what I would face. Actually, you shared the roles with your explanations, but… Frankly, I was a little hesitant to take on the roles since I did not know much about the process, and I had not participated in such an event before. I think a little more detail could have been given about the roles to be assumed in the process. At first, I could only perceive the given things by name, but I could not understand exactly what to do in the given job descriptions." [181]

Regarding performing the roles, the effect of orientation about the roles was also described as follows:

> "I do not think that I was able to perform it adequately, as the details of the task were not well understood in the meeting where the tasks were shared." [182]

Another teacher suggested a meeting for learning the details about the roles as follows:

> "Maybe there was a need for a meeting where the roles were introduced in more detail. It would reinforce the group's own decision-making process." [183]

Switching roles through activities

To maintain online CoP through roles, switching roles through activities was suggested by teachers (*n*=5, *f*=14). Although the fact that they could switch roles whenever they want was said at the beginning of the program, teachers did not switch the roles throughout the process. One of the participants stated her opinion by stating the following:

> "We distributed roles to our volunteer teachers, but I remember that these roles will change later. I don't think there was such a change… It could have been changed for the better. Everyone would be more actively involved in the process." [184]

Another participant suggested that switching roles through the activities could be stated as a rule for participation. A sample quote in this issue is as follows:

> "I think it would be much more impressive to put that as a rule that the roles will be switched in the second activity. Just as with students, it is necessary to speak with sharp lines to adults as well." [185]

Moreover, one teacher emphasized the role of orientation about the roles. It was described that it would help switch roles throughout the activities.

4.4.2.4 Suggestions related to online CoP

The interviews indicated teachers' suggestions about maintaining online CoP. The emerged categories are collaborating with an academician, peer observations, adding some time between planning and implementation, working with the only one small group, and attending two teachers from the same school.

Collaborating with an academician

The need of getting support from an academician who is an expert in this topic was described (*n*=1, *f*=10). One of the participants shared her ideas about collaborating with an academician through the activities of online CoP by stating the following:

> "Maybe an academician could have told us the theory part explained in the video. It could be a meeting and mingling environment, and we could ask the questions in our minds…We are not always the ones who do everything right, we actually want to get support from a superior. Sometimes even small comments could make it enjoyable in those plans. This could have enabled us to take a more active role or become a participant. Just as I guide the child, I also need a guide in that sense." [186]

Peer observations

To benefit from other lesson plans' implementation and enrich collaboration between teachers, peer observations were suggested (*n*=1, *f*=4).

> "Rather than telling us about the implementation of another group, activities that are possible and that we can participate as observers at a determined time can be organized. Because it is now possible to attend every online course. Maybe not in the sense of watching or evaluating a lecture during a presentation to your students, of course, not in terms of how you did this or how you did that. I think such interaction can be increased in terms of observing and experiencing." [187]

Adding some time between planning and implementation

During the activities, teachers were expected to design a lesson plan collaboratively and implement the lesson plan in their classrooms. These steps were done successively within the semester. In this process, the need of adding some time between planning and implementation was suggested (n=1, f=4). A participant shared her thoughts in this regard as follows:

> “There may be some time between planning and implementation. For example, this year, we could have worked on excel and Scratch for a longer time and worked on what we could do. We could put the lesson plans into practice next year, or if we had studied in the first semester and applied in the second semester, then I'm sure the process would have gone faster. Because we started in the middle of the semester in October. The process is already online, there were already a lot of changes, and we were having a hard time.” [188]

Working with the only one small group

There were 24 elementary mathematics teachers, and 24 ICT teachers that participated in the online CoP. Four small groups had worked on their lesson plans collaboratively. During online CoP, working with the only one small group was suggested by one participant to increase the quality of interaction. A sample quote is as follows:

> “Also, we were a very large group in this study. We were divided into small groups amongst ourselves. Perhaps this could be piloted with a smaller participation, as has been done before.” [189]

Attending two teachers from the same school

Another suggestion was based on the number of participants from the same school. In this study, there were one mathematics and one ICT teacher from each school. While the small group consisting of various schools were working together to design lesson plan, the mathematics and ICT teachers from the same school were working on the implementation of the lesson plan regarding necessary preparations. A teacher suggested to attend the online CoP as two mathematics teachers from the same school to increase the interaction (*n*=1, *f*=1). She stated her opinion by the following statement:

> "At least 2 teachers can be selected from the same school, both in terms of sharing ideas and togetherness." [190]

4.4.3 Gains from Online CoP

The opinions of the teachers about what they gained from participating online CoP were analyzed as a guide for the instructional design of teacher professional development programs on technology integration. The results of these analyses have been reported in four themes: gaining knowledge, experiencing, collaboration and sharing. The number of participants stated the relevant theme, and the frequency of statements are given in Table 4.4.3.

Table 4.4.3 Gains from Online CoP

Themes	**Number of participants (*n*)**	**Frequency (*f*)**
Gaining knowledge	24	256
Experiencing	24	154
Collaboration	23	164
Sharing	22	236

Total number of participants: 24

Gaining knowledge

The first category extracted from the interviews related to the teachers' gains from the online CoP is gaining knowledge (*n*=24, *f*=256). All the participants highlighted that they gained knowledge through participating in this online CoP. These gains are related to the cognitive tool concept and constructivist learning environments by means of the video about the constructivist learning environments and sample lesson plans, and Scratch by means of the webinar and related activities.

Most of the teachers stated that the video explaining the concept of cognitive tools and constructive learning environments became a preliminary study for them before examining the sample lesson plans. A teacher stated her opinion as follows:

> "We actually saw what our point of view was there. We know the constructivist approach, but we have seen how we should handle technology while integrating it." [191]

The activities related to examining sample lesson plans were also described as a mean for gaining knowledge. The relationship between the theory and practice was highlighted through examples. One of the teachers shared her opinion in this issue by the following statement:

> "But actually, we understood how the cognitive tool had an effect in understanding mathematics by seeing those examples." [192]

Sample lesson plans were considered as a guide for the next step of the professional development program which is designing a lesson plan integrating a cognitive tool.

> "The examples were actually very helpful. Because since you have not made a similar plan before, there is a concern about where to start. But when you have an example in front of you, it can evoke meaning. Or you are similarly looking for an example of daily life. As you use that cognitive tool, you see how you can pose questions to students on the activity sheet. You see where and how clues can be given. You see what the role of the teacher is when the students are working as a group. The examples are very instructive. We rarely make such lesson plans after all. At the same time, we see how we can benefit from a new technological tool. Each step within the model was noted in the examples. It helps us concrete." [193]

As well as using them as a guide while integrating cognitive tools into their lessons, one of them shared that the sample lesson plans would be helpful for the application of constructivism in his lessons by stating the following:

> “So, the lesson plan, lesson plan examples were very effective for me. In other words, whether I use any technological tools or not, I think that I will use lesson plan examples in the lesson plan preparation phase from now on and make my plans more active.” [194]

Another point highlighted as a source of knowledge are the activities related to learning Scratch. In the program, teachers were expected to use Scratch as a cognitive tool. So, there were some activities to learn the tool before examining a sample lesson plan and designing a lesson plan including Scratch. Those activities included a webinar led by an ICT teacher explaining the basics of the tool and two projects that participants could work on collaboratively with the ICT teacher in their school.

Some teachers emphasized that the webinar helped them understand the basics of the tool. A sample quotation in this topic as follows:

> “It was definitely instructive. For example, I can say that I started from scratch. It was very instructive to introduce the things to be used there and to tell how to use them appropriately. With what I watched there, of course, I was able to come up with a product by a little trial and error myself.” [195]

The recording of the webinar was also considered as useful while doing the practice activities. On the other hand, the webinar was not stated as effective by some others because of its scope, some technical problems they faced and the speed of the presentation, but the practice activities collaborating with ICT teachers helped them learn the tool.

> “But I couldn't write those programs from scratch by myself, that's all. I couldn't have done it just by watching it. For this level, it may be necessary to concentrate and deal with the program for a few months. But we were able to develop the program together with our ICT teacher, based on the draft that was sent. Then it was easier to understand the use of Scratch.” [196]

Experiencing

The second category extracted from the interviews related to the teachers' gains from the online CoP is experiencing (*n*=24, *f*=154). All the participants highlighted that the experience of planning a lesson integrating a cognitive tool and implementing it in classroom was a critical achievement for their professional development in integration of cognitive tools.

A sample quote about the significance of practical experiences while learning how to integrate a cognitive tool as follows:

> "Therefore, the activities within the scope of this training gave us practical experiences. In order to use a tool as a cognitive tool, what should we pay attention to, how should we plan the lesson, what should we do while applying it." [197]

Moreover, some participants highlighted the experience of how it works in classroom through different examples. This experience of planning and implementation was considered as a source of self-confidence while integrating cognitive tools in future. One of the teachers stated her opinion as follows:

> "I saw the effect when I applied it to students. Having professional knowledge on this subject and examining and applying different examples in the use of technology contributed a lot." [198]

Moreover, in order to integrate Scratch as a cognitive tool, they also experienced how to use the tool after gaining knowledge from the webinar. A teacher stated her opinions about the practice activities by stating the following:

> "Then she gave us an assignment so that we can prepare it ourselves. I also enjoyed it more while doing it step by step there. I thought I could do something too." [199]

Collaboration

The third category extracted from the interviews related to the teachers' gains from the online CoP is collaboration (*n*=23, *f*=164). Nearly all of the participants emphasized collaboration during the online CoP.

Regarding the process of creating a new lesson plan based on cognitive tools, which is a newly learnt concept, teachers stated that they need support from both other mathematics teachers and ICT teachers. The teacher professional development activities allowed them to work together. A teacher shared her opinions in this regard as follows:

> "Of course, still the part of producing something on our own was difficult. In this part, both working with mathematics teachers and ICT teachers made it a little easier. I wouldn't be able to produce something new right away on my own..." [200]

Moreover, working with teachers from other schools was considered as an enrichment. Participating in online CoP provided them chance to collaborate with different teachers. One of the teachers highlighted this by the following quote:

> "Yes, we are always together with our department, we are always in teamwork with them. But this was a different teamwork for me. In this program, I had the opportunity work with teachers from different schools. We saw others' perspectives, we produced new ideas." [201]

On the other hand, collaborating with ICT teachers during the remote emergency period became difficult. The activities required them to work on the implementation plan together, however, finding time to collaborate remotely was stated as harder than planning it in a school environment. A sample quote in this issue is as follows:

> "Well, coinciding with this process made it difficult. I work from home, you know, two teachers need to be in contact. We couldn't get together with our ICT teacher. You know, we could have been more comfortable if it was in a school environment. So, this pushed a little and extended the process." [202]

Another collaboration problem was stated as the lack of participation of ICT teachers during planning lessons. This was seen as a cause of delays in decision making. Teachers considered that they needed support from ICT teachers to decide whether the students could use the cognitive tool in that way or not. A participant shared her thoughts by stating the following:

> "Maybe informatics teachers can also support us in choosing this outcome and how we can relate it. Because very few ICT teachers took an active role in the group. They only supported our internal planning at school. In fact, they had actively participated in those meetings, maybe we could made decisions much faster." [203]

Regarding the delays in decision-making while collaborating, a teacher suggested to be given the objective that they will work on. According to her, it made the process longer.

Sharing

The fourth category extracted from the interviews related to the teachers' gains from the online CoP is collaboration (*n*=22, *f*=236). Most of the participants emphasized the significance of sharing during the online CoP.

Examining sample lesson plans and sharing their thoughts were considered as a great contribution for their professional development. One of the teachers explained her ideas in this regard as follows:

> "Teachers, who expressed their opinions, made very valuable contributions. With their own experiences and what they brought from their own schools… This of course had a positive effect." [204]

Sharing opinions related to the implementation of the same lesson plan within the small groups contributed teachers' evaluation of the lesson plan thoroughly. In the interviews, they shared that sharing their opinions about the implementation increase their awareness. According to them, it helped them see other experiences. A sample quote as follows:

> “When everyone applied the lesson plan we developed in their own school, we saw what we experienced similarly, whether there were any problems or similar conveniences. It made more sense to me to concentrate on one such lesson plan instead of different lesson plans.” [205]

Furthermore, sharing the lesson plans and opinions based on the implementation of these lesson plans between groups provided various examples and feedback that can be applied before implementing them. A teacher shared her thoughts by stating the following:

> “The best part was that everyone shared their lesson plans after they had experienced them. After that experience, saying that this is like that becomes a spot on the mark for us. The fact that it has been implemented gives us even more information.” [206]

The supportive role of online CoP for teachers was highlighted for some teachers who may not have chance to collaborate with other mathematics teachers within their school. Because s/he could be the only one in the department. A teacher stated her opinion in this regard as follows:

> “I mean, sometimes we don't have such a team in our school. Therefore, establishing such a communication with other schools and listening to the practices there or hearing the ideas show us a way, an idea. Why not us too? There is enthusiasm for our work again. [207]

4.4.4. Change in Opinions Related to Technology Integration

The interviews indicated the change in teachers’ opinions about technology integration by participating in this program. The change in their opinions were analyzed in seven themes: learning new approach, new tools, questioning the role of technology integration, perceived level of technology integration, lesson planning, willing to integrate technology, and teachers’ adaptation. The number of participants stating the relevant theme and the frequency of statements are given in Table 4.4.4.

Table 4.4.4 Change in Opinions Related to Technology Integration

Themes	**Number of participants (*n*)**	**Frequency (*f*)**
Learning new approach	24	161
New tools	22	72
Questioning the role of technology integration	20	67
Perceived level of technology integration	15	36
Lesson planning	14	35
Willing to integrate technology	12	34
Teachers' adaptation	11	36

Total number of participants: 24

Learning new approach

Regarding a change in their perspective, all the participants emphasized that this teacher professional development program made them learn a new approach (*n*=24, *f*=125) while integrating technology. A sample quote is as follows in this regard:

> "It has broadened my perspective and broadened my horizons. So, for example, I realized that I was stuck in very narrow things. I'm stuck with a few apps. But I saw that I could do different works with very different applications." [208]

One of the participants compared her technology integration practices with the integration of cognitive tools by stating the following:

> "There was no example that I also used as a cognitive tool. Similarly, I was using technology to make it easier for students to understand some subjects. But in these studies, the student did not produce a product or did not have a detailed planning process like the lesson plans we studied in cognitive tool use." [209]

According to interviews, learning constructivist learning environments by integrating cognitive tools made them perceive technology integration in another way. Through this approach, the effect of technology in students' understanding mathematics was discovered. Moreover, teachers who were afraid of integrating technology and considering it as difficult changed their minds. A sample quotation indicates this change in opinions:

> “For myself, I saw that something can be done in terms of technology, and that it is not very difficult in mathematics.” [210]

New tools

Another change in their thoughts about technology integration is adding new tools (*n*=22, *f*=72) into their repertoires to use in their mathematics lessons. According to interviews, as well as integrating technology with a traditional approach, there was a limited use of tools in mathematics lessons because they thought that mathematics as a lesson was not appropriate for integrating technology.

> “The training program made it easy for us to associate programs we know with mathematics, such as Excel and Scratch.” [211]

Majority of the participants stated that they did not have any experience in integrating Excel and Scratch in their classrooms. Although they know how to use Excel, most of them did not know how to use Scratch. Two sample quotations are as follows:

> “I was already using it myself, when creating tables, evaluating children. I noticed it. But putting this into education, using excel in education… This is the part that excited me the most. I think it was enjoyable to put the things that everyone knows, the materials in the kitchen on the counter and come up with something.” [212]

> “I didn't know Scratch as a program before. For example, I was using Excel, yes, but I never thought about the mathematical side.” [213]

Questioning the role of technology integration

Another theme that they changed their mind throughout the activities of online CoP is questioning the role of technology integration (*n*=20, *f*=67). Most of them shared their experience as integrating technology for students’ motivation and active participation. Even they integrated it for helping students' understanding, they pursued a traditional approach which is teacher centered.

In this issue, a teacher stated her questioning the goal of technology in mathematics classes. Although she knew technology can be integrated to help students' understanding, she mentioned that she could not apply this approach into their lessons before this online CoP. A sample quote is as follows:

> "I could not accept that technology is something we apply just for fun or to make a difference to children. This is something I always questioned. Ok, technology is very nice, but let's not use it for the sake of having it. Or it was at a point where I said not to use it just for fun. It got me very excited about this idea. In fact, we tried and saw that technology can serve mathematics, how I can integrate Excel, how I can integrate Scratch." T05 – 4

Teachers accepted that technology made facilitation easier in classroom. Even in traditional approach, it was used as a motivator. In general, technology was integrated into lessons to attract students' attention, assess their progress easily, and drill-and practice. One of the participants share her experience by stating the following:

> "While integrating technology, I did not take it so holistically in my previous lessons. I was just taking advantage of the features of the tools." [215]

Teachers discovered the role of cognitive tools in students' learning and how it can be integrated with this purpose. One the other hand, most of the teachers specified that the traditional approaches would also be used based on the needs. But integrating technology as cognitive tools became an option for them to enhance students' learning and create an environment where they can produce a product. One participant stated the following in this issue:

> "Of course, there is no end to technology. There are many different programs. But the important thing is to use the right technology in the right place and to use the right program." [216]

Perceived level of technology integration

Teachers changed their mind about the perceptions about level of goal of technology integration (*n*=15, *f*=36). While emergency remote learning period during the pandemic forced them to use technology, the online CoP helped them see that their use was limited.

> "… I was thinking that I was very good at technology. But I realized that I am not that much." [217]

Teachers shared that the level of technology integration was very low in their classes before the pandemic. Most of them stated the need for training programs related to technology integration in mathematics classes. The technology integration was considered as a task requiring high level of use. So, this approach limited technology integration in classes. The online CoP indicated that they could integrate cognitive tools without advanced knowledge of technology. One of the teachers shared her opinions in this regard as follows:

> "I still have many deficiencies, but we have gained a perspective. We saw that it was not that difficult. We saw that it needed some attention." [218]

Lesson planning

Teachers' way of lesson planning was affected by the sample lesson plans and the designed lesson plans including cognitive tools (*n*=14, *f*=35). They mentioned that their planning strategies for both technology integrated lessons and other lessons were influenced.

For technology integration, teachers realized the significance of a good planning before the implementation. Through a detailed plan, teachers integrated a cognitive tool into their mathematics lessons easily. They observed the effect of lesson planning in technology integration. One of the teachers shared her opinion as follows:

> “But of course, I saw that there was a need for planning beforehand, even a very good planning.” [219]

Moreover, another effect was stated as their lesson planning strategies. Some of them mentioned that they used to make weekly planning covering the objectives they need to focus. However, after the participation of online CoP, they started to make lesson plans. Some of them revised their existing plans by elaborating details. A teacher mentioned this change in her practice by stating the following:

> “I was looking at the status of my weekly plans, whether I finished the objective or not, and I was writing one after the other. Now I have started to divide lessons. This worked for me.” [220]

One of the teachers emphasized the role of sample lesson plans in planning lessons with a constructivist approach. A sample quote in this regard is as follows:

> “Especially when creating an activity sheet at work, for example, when creating an activity sheet within a lesson plan, the lesson plans we saw while making these implementations set an example for me. I just recorded them. From now on, I will definitely make use of it when creating any lesson plan. Based on Jonassen's constructivist approach, we can create the activity sheet that way…. In other words, we were already using it, but we were not using it that effectively, it wasn't exactly that efficient.” [221]

Willing to integrate technology

Willingness to integrate technology in their classes is a theme extracted from the interviews (*n*=12, *f*=34). Interviews indicated that teachers’ positive attitudes towards technology integration was ongoing. One of them shared her opinion in this regard as follows:

> “A little more, actually, my enthusiasm increased, my enthusiasm increased. I can say that I am motivated to use technology.” [222]

Moreover, remote emergency learning period also affected their opinions related to technology integration. After that period, learning how to integrate technology to help students understanding became an interesting topic. One of the teachers stated her interest in this training program related to technology integration by stating the following:

> "As I just mentioned, my perspective on technology before the pandemic and my current perspective is quite different. Therefore, I showed more interest in this training." [223]

Participating in the online CoP and learning to integrate technology as cognitive tools changed their opinions about technology integration. Mostly, technology used to be integrated to motivate students and assess their understanding with a teacher-centered approach. A sample quote showing this change is as follows:

> "The part that changed is that I decided to use more technology. Because it can really be used as a cognitive tool. I mean, we used to do something and show it to the kids. Now we get the kids to do it. It changed positively." [224]

Teachers' adaptation

Teachers' adaptation is another theme that teachers mentioned throughout the interviews (*n*=11, *f*=36). The role of technology for students in their lives, the technological advancements, and the events like pandemic that involve technology into our lives more required teachers' adaptation to technology integration.

Regarding the role of technology for students in their lives, one of the teachers stated her opinions about why teachers need to integrate technology by stating the following:

> "It is an advantage for us that they can relate mathematics to the technology language they speak. We have to get used to that language too." [225]

With the effect of pandemic, teachers needed to adapt their teaching and integrate technology into their classes. This also affected their opinions related to technology integration. Most of the teachers emphasized that they needed to learn more how to integrate technology effectively. A sample quote is as follows:

> "After all, technology is indispensable, especially with this pandemic. Maybe we were using it, or some branches were using it more actively. But now we are at the indispensable point. It is not possible to resist this, in the current process we live in." [226]

4.4.5. Technology Integration (Prior to the study)

Teachers expressed their ways of integrating technology prior to the study during the final interviews as well as they did in the initial interviews. Teachers' technology integration practices were analyzed, and the results have been reported in these themes: Assignment, motivation, web 2.0 tools, visualization, simulation, videos, emergency remote learning, drill and practice, instructional delivery, and students' projects. The number of participants stated the relevant theme, and the frequency of statements are given in Table 4.4.5.

Table 4.4.5 Technology Integration (Prior to the study)

Themes	**Number of participants (*n*)**	**Frequency (*f*)**
Assessment	14	22
Motivation	12	23
Web 2.0 tools	9	20
Instructional delivery	6	14
Videos	6	10
Visualization	6	9
Simulation	5	15
Drill and practice	4	11
Students' projects	3	6

Total number of participants: 24

Assessment

One of the ways that teachers integrated technology is assessing students' understanding and skills in class (*n*=14, *f*=22). A teacher stated her way of integration by stating the following:

> "But when I thought about the lesson plan preparation process, I generally used the tools I mentioned for assessment and evaluation in order to understand how much they understood that lesson in class. Or I was checking to see what they knew when I entered a class." [227]

While they were aiming to identify students' understanding through some web 2.0 tools, one of the teachers emphasized that it was not effective. A sample quote in this issue is as follows:

> "I mean, I used to use Kahoot very rarely, but it wasn't very effective either." [228]

Motivation

Interviews indicated that teachers integrated technology for motivating students during classes (*n*=12, *f*=23). Technology was integrated to attract students' attention to the topic, increase their motivation when they got bored, and make them participate through games and competitions in a teacher-centered way. On the other hand, teachers mentioned the decrease in students' motivation towards the technological tools that they had used before. The emergency remote learning period affected teachers' integration of technology for motivational purposes. However, students had lost their motivation towards technology in that way. One of the teachers expressed this situation by stating both students' and her perspective:

> "So, we will definitely go with technology. But how much I will use, what extent, what subject, frankly, I haven't made a plan right now. It could also be due to some boredom. … I don't think the kids will either. Because in every activity we do, they started to say 'Is this again? In the previous lesson, the other teacher used it." In other words, we actually use a tool so that they can learn and have fun, but we see that it was made in another lesson, it does not have the same effect on the children. They don't want to use it or are looking for something new." [229]

Web 2.0 tools

Regarding teacher's practices related to technology integration, web 2.0 tools were frequently used by teachers in their lessons (*n*=9, *f*=20). Teachers stated that there were plenty of web 2.0 tools they can use in class, they learned them by searching themselves, and they used them based on their needs and students' age groups in a teacher-centered way. During emergency remote learning period, they stated that they benefited from web 2.0 tools for several purposes such as motivation, drill and practice, and assessment in classes.

Instructional delivery

Before the pandemic, teachers shared that they used technology for instructional delivery (*n*=6, *f*=14). In general, they prepared presentations, worksheets, and tables by using MS Office programs. They used smart boards in class while presenting. Moreover, one of the participants stated that she used tablets while facilitating instruction.

During the emergency remote learning period, teachers maintained their classes remotely through synchronous video conferencing programs. Some of them highlighted that remote teaching would be a part of their job after this period. A sample quote in this regard as follows:

> "But now, when we think of school or administration, of course, this technology will definitely not be out of our lives anymore. For example, there used to be a snow holiday, it doesn't exist anymore. It will now be directly online. So, this is how education will continue with technology." [230]

Videos

Videos also take place in teachers' technology integration practices (*n*=6, *f*=10). They stated that they benefited from videos in order to attract students' attention, help students imagine some abstract topics, and help them understand. One of the teachers explained his way of use videos by stating the following:

> "Yes, we use technology, but we used the technology in the lesson by using the video monitoring feature of the smart board." [231]

Visualization

Interviews showed that teachers integrated technology in their classes to help students concretize mathematics subjects with a teacher-centered approach (*n*=6, *f*=9). In these practices, teachers benefited from Excel or Word to construct tables and graphics, some programs like GeoGebra to show geometry topics. A sample quote indicating technology integration practices for visualization as follows:

> "I mean, I was mostly using Excel for things, graphics. For example, we are currently in data collection. We were already using Excel, Word or graphics there while creating their tables and column charts." [232]

Another quote shows the active role of teachers in integrating technology as follows:

> "We used to reflect the GeoGebra on the blackboard, distribute compasses to the whole class, and do activities on subjects such as drawing triangles and the angle-side relation at 8-grade classes." [233]

Simulations

According to the interviews, simulations are another way of teachers integrate technology in their classes (*n*=5, *f*=15). In general, teachers use simulation programs such as GeoGebra in smart boards, ask a few students to come and try. Through observing the results of the actions they have made, simulations help students' understanding. One of the participants compared the use of simulations with the use of cognitive tools by stating the following:

> "In that program, we can make students do various applications. Students can determine the variables themselves and observe the results of their applications... But as in this study, the student does not produce a product himself." [234]

Drill and practice

Another technology integration practice that teachers mentioned is based on drill and practice (*n*=4, *f*=11). Teachers preferred to use some programs in class to help students practice what they learned. A participant explained how drill and practice programs help students' learning by stating the following:

> "It enables the student to use and apply the knowledge they have learned at that moment." [235]

Students' projects

Interviews indicated that teachers integrate technology in their teaching by assigning student projects that require students' creation of a product by using technology (*n*=3, *f*=6). For instance, students use technology to create a poster about a given topic in these projects. One of the teachers shared her use of a program in students' projects as follows:

> "There, students could design posters and the like in Canva. But we made a plan like this in our lesson. Students would create a daily life example on the subject of intersection of the sets they learned in the mathematics lesson. Then they would create and design that real-life example of Venn diagram in Canva. In this direction, very good examples have come to us." [236]

4.4.6. Teachers' Opinions Related to Teacher Professional Development

The interviews indicated teachers' opinions about teacher professional development on technology integration after participating in this program. The results were reported in six themes: enhancing experiential learning, prior experience, sequence of activities, long duration, and flexibility. The number of participants stated the relevant theme, and the frequency of statements are given in Table 4.4.6.

Table 4.4.6 Teachers' Opinions Related to Teacher Professional Development

Themes	**Number of participants (*n*)**	**Frequency (*f*)**
Enhancing experiential learning	15	28
Prior experience	10	23
Sequence of activities	5	14
Long duration	3	3
Flexibility	1	2

Total number of participants: 24

Enhancing experiential learning

Teachers stated the role of experiencing while learning how to integrate technology as cognitive tools through online CoP regarding teacher professional development (*n*=15, *f*=28). Participating teacher professional development activities that allow teacher experience designing and implementing a lesson plan integrating technology contributed their professional development. One of the teachers stated her opinion as follows:

> "Actually, this training was like a little experiment. We created the lesson plan, but we saw how it went in class." [237]

Moreover, teachers highlighted that experiencing technology integration was more effective and efficient in professional development programs since it provides confidence in integrating technology and shows what could be improved and how it could be maintained in comparison to trainings telling what can be done in technology integration. A sample quotation in this issue is as follows:

> "I think it was much more efficient. So, in such an hour, yes, all of them can be talked about, but you can't really understand without application. So, it has to be implemented." [238]

Prior experience

The interviews indicated teachers' opinions about their prior teacher professional development experiences about technology integration after participating in this program (*n*=10, *f*=23). While most of them stated that they had not been participated in such an online CoP targeting technology integration, they also highlighted the recipient role for teachers in their previous experiences.

Examining sample lesson plans in their branch and experiencing design and implementation stages of lesson plans integrating technology were stated as deficiencies in their previous professional development experiences. Furthermore, the significance of examples in their branch was emphasized. One of the participants shared his perspective by stating the following:

> "In the trainings I attended before, they count to us that these can be used, that they can be used for this or that purpose. But when we look at it again, there are points in our branch that we think about what and how. In fact, when the name of the program is unfamiliar, yes we can use it, but how to use it becomes a question mark and remains that way." [239]

On the other hand, one of the teachers shared that she learned from her colleagues' technology integration experiences by following them on social media and attending their workshops. She found their examples showing how to integrate technology as helpful. A sample quote of hers is as follows:

> "Frankly, I use social media a lot in this regard. In other words, I follow the practices of my colleagues and they also organize trainings from time to time. I meet with them and even learn the applications there. Especially for this Apple's applications, Apple Teachers organize trainings, I try to join them. Or they share the good practices they use in their own lessons, the ones they discover." [240]

Sequence of activities

Regarding the teacher professional development program about cognitive tools, teachers stated the role of sequence of professional development activities in effectiveness of the program (*n*=5, *f*=14). By following the activities one by one, their understanding about how to integrate cognitive tools was shaped. A sample quote in this regard is as follows:

> "Each study was a preparation for the next. If there was no training, maybe if we had examined the sample lesson plan directly, we would have had more difficulties. Each one was very precious." [241]

Similarly, another teacher compared her process of creating a product in this online CoP with the design process of a constructivist lesson plan for a best practices conference in her institution. The aim of the conference that she attended was stated as providing teachers professional development about designing constructivist lesson plans by allowing them to experience the design and implementation and sharing their experiences. She emphasized the sequence of professional development activities by comparing these two programs as follows:

> "These stages were invaluable to the learning process. The sequence was very accurate. … At the conference I attended the previous year, these steps were always missing. Again, a product was expected from us. But the sections on understanding what was wanted, seeing examples, and working together before creating the product were missing." [242]

Long duration

Some teachers stated the teacher professional development program they attended in this study had a long duration (*n*=3, *f*=3). While emphasizing the long duration of the program, they considered the program effective and rewarding. One of the participants highlighted the effect of pandemic in program's duration and shared her opinion in this regard as follows:

> "The process is actually so beautiful and although it took a little longer despite the pandemic, it went so well…" [243]

Flexibility

Flexibility is another topic mentioned by one of the participants. The interview indicated that participating this online CoP during ongoing instability because of pandemic required more flexibility on the steps of the program. A sample quote in this issue is as follows:

"In addition, during the entire program, necessary flexibility was provided according to the pandemic conditions. If it were not provided and this logic of step-by-step progress had not been established, we would definitely be fed up and could not follow the process." [244]

4.5 Summary of Results

In line with the research questions, this chapter revealed the results of what the opinions of teachers on technology integration in mathematics teaching are prior to the implementation of the online CoP and how this teacher professional development about the integration of technology as cognitive tools affects teachers' technology integration as cognitive tools in mathematics teaching. Figure 4.5.1 and 4.5.2 present the results of these three main research questions and the related sub-questions.

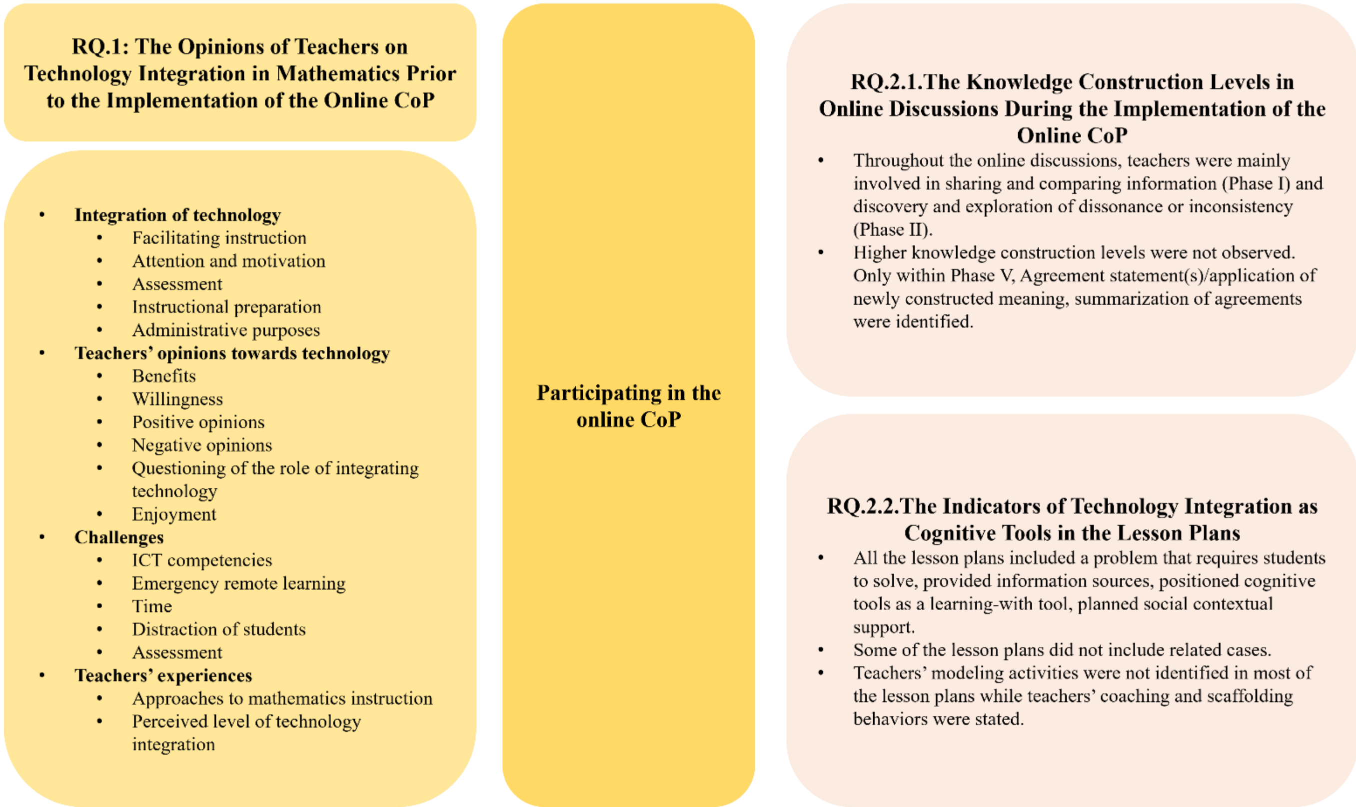


Figure 10 The summary of results related to research questions - 1

RQ.3.The Opinions of Teachers on the Impact of Participation in Online CoP on Their Technology Integration Practices as Cognitive Tools

- **Constructivist learning environments**
  - The effect on students' learning
    - Learner attention and motivation
    - Constructionism
    - Understanding
    - Active participation
    - Integration of mathematics and daily life
    - Integration of mathematics and technology
    - Collaboration
    - Developing thinking skills
    - Easing task
    - Autonomous learners
  - Integration of cognitive tools
    - Willingness
    - Increasing duration of the lessons
    - Integrating to yearly plan
    - Determining appropriate cognitive tools
    - Face-to-face implementation
    - Desire to implement peers' lesson plans
    - Desire to use variety of cognitive tools
    - Planning with ICT teachers
    - Desire to share with others
    - Working with different grades
    - Integrating cognitive tools in different subjects
    - Assessment
    - Designing shorter lesson plans

,

  - Challenges of integrating cognitive tools
    - Teachers' competencies
    - Online implementation
    - Extra time for planning
    - Curriculum
    - Preparing students' national exams
    - Limited ICT lesson duration
    - Workload of ICT teachers
  - Readiness of students
    - ICT readiness
    - Mathematics readiness
  - Teachers' role in constructivist learning environments
    - Support for students
    - Facilitation
    - Classroom management
  - Change in students' attitudes
    - Towards ICT
    - Towards mathematics
- **Maintaining online CoP**
  - Participation of teachers
    - Workload of teachers
    - Active participation of teachers
    - Changes in motivation
    - Instability because of pandemic
    - Time during working hours
    - Willingness to attend similar online CoP
    - Delegating the duties
    - Face-to-face participation to CoP
  - Interaction between teachers
    - Interaction
    - Communication
    - ICT related issues
    - Novelty
  - Functioning of roles
    - Distribution of the roles
    - Performing the roles
    - Roles to maintain online CoP
    - Extra time for the roles
    - Orientation
    - Switching roles through activities
  - Suggestions related to online CoP
    - Working with different grades
    - Collaborating with an academician
    - Peer observations
    - Adding some time between planning and implementing
    - Working with only one small group
    - Attending two teachers from the same school
- **Gains from online CoP**
  - Gaining knowledge
  - Experiencing
  - Collaboration
  - Sharing
- **Change in opinions related to technology integration**
  - Learning new approach
  - New tools
  - Questioning the role of technology integration
  - Perceived level of technology integration
  - Lesson planning
  - Willing to integrate technology
  - Teachers' adaptation
- **Technology integration (Prior to the study)**
- **Teachers' opinions related to teacher professional development**
  - Enhancing experiential learning
  - Prior experience
  - Sequence of activities
  - Long duration
  - Flexibility

Figure 11 The summary of results related to research questions - 2

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 Major Findings and Discussion

5.1.1 The Opinions of Teachers about Technology Integration Prior to the Implementation of Online CoP

Integration of technology

Teachers benefit from technology in classrooms to support learning and teaching processes and it is defined as teacher technology integration (Inan & Lowther, 2010b). The way of teachers' use of technology for student-centered learning and personalized learning established the quality of teachers' technology integration (Cheng, Lu, Xie & Vongkulluksn, 2020; Hsu, 2016). In this regard, Jonassen (2000) categorized technology integration into two groups based on the role of the technology in learning process. First one is *learning from technology* and the other one is *learning with technology*. While learning from technology positions technology in a teacher-centered environment in which students take passive roles in their learning, learning with technology embraces technology as a tool that supports students' meaning making (Jonassen, 2000).

The findings of the initial interviews conducted before the implementation of online CoP indicated that teachers integrated technology into their lessons for facilitating instruction, attention and motivation, and assessment as well as they benefit from technology for instructional preparation and administrative purposes (See Table 4.1.1.). In this study, the participants stated that they integrated technology to facilitate instruction and the most stated way of integration was instructional delivery. Teachers also mentioned that they integrated technology to prepare their lessons, to implement assessment and drill and practice activities and incorporate videos. These findings highlighted the technology integrated practices of teachers positioned themselves active in mathematics classes where students took a passive role. Similarly, other studies indicated that ICT integration in mathematics instruction consisted of teacher-centered activities that would assist and improve students' learning and advancement (Alshehri, 2012; Dick & Hollebrands, 2011).

The practices integrating technology to engage learners as active participants in a student-centered learning environment allow learners to involve in self-directed tasks and adaptive learning as suggested by Lee and Hannafin (2016). Even though teachers incorporated technology for attention and motivation of students and engaging them in mathematics lessons, their technology integration is mostly based on teacher-centered activities such as drill and practice activities, integrating videos, and activities helping students visualize concepts. Some of the participants stated that they integrated simulation activities to allow students to observe changes, most of them are based on teachers' display in a classroom setting rather than allowing students' discovery in student-centered environment. So, the results revealed that teachers integrated technology by embracing it as a learning-from medium. The integration of technology with a traditional approach is in line with the findings of previous studies which teachers preferred to do so to complement their traditional ways of teaching (Mwalongo 2011; Thorvaldsen, Vavik & Salomon, 2012). Hence, it can be deduced that teachers lack learning with technology approach in their technology integration practices.

Opinions about technology integration

In general, attitude refers to a personal judgement about something, which can be positive or negative (Fiske, 2010). In technology integration, the attitudes of teachers towards technology identifies the process of technology integration as one of the internal factors (Chiu & Churchill, 2016). A recent literature review reveals that teachers' attitude towards technology integration were measured with common constructs such as enjoyment, confidence, anxiety, and their position towards technology integration in survey scales (Njiku, Maniraho, Mutarutinya, 2019). Considering the role of teachers' attitudes towards technology integration in their practices, this study focused on teachers' opinions about technology integration by conducting interviews before the implementation of online CoP.

Regarding teachers' opinions about technology integration, teachers mentioned the benefits of technology integration in terms of increasing attention and motivation, increasing efficiency, resources, helping cognitive processes, and learning from technology; their willingness to integrate technology, their positive opinions, negative opinions, questioning the role of integrating technology, enjoyment, and their opinions about cognitive tools (See Table 4.1.2.).

The findings of the current study indicated that teachers considered that technology integration has benefits in *increasing attention and motivation*. Although these terms have different meanings, teachers used the terms in their expressions interchangeably. Hence, the related analysis could not categorize them effectively, and discussed them together. The most frequently used theory to explain *motivation* in technology enhanced learning environments is Self-Determination Theory (Dreimane, 2019). According to the theory, there is a taxonomy of motivation which includes intrinsic and extrinsic motivation (Ryan & Deci, 2000). The taxonomy starts with amotivation which consists of low perceived competence, non-relevance, non-intentionality. It continues with the four levels of extrinsic motivation. For extrinsic motivation, the first level is external regulation, and it consists of salience of extrinsic rewards and punishments. Second level is introjection which is related with ego involvement and approval from self and others. Third level is identification, and it includes self-endorsement of goal and conscious valuing of activity. The fourth level is integration, and it contains hierarchical synthesis of goals and congruence. Finally, intrinsic motivation comes in the taxonomy, and it is associated with interest, enjoyment, and inherent satisfaction of an individual. The results of the current study highlighted the role of technology in learners' livings. The teachers stated that learners had interest in technology, and they feel enjoyment in the lessons integrating technology. Technology integrated lessons motivated them to learn and participate in the learning activities. Hence, learners' motivation can be considered as intrinsic motivation based on Self-Determination Theory. Even though mathematics is a lesson which most of the students are afraid of, ICT integration was considered as a motivation source for mathematics lessons.

Moreover, the teachers stated that they integrated technology to attract students' *attention* into the course material. In this regard, Weber (2003) stated that teachers could prevent the potential negative learning results caused by lack of students' motivation by influencing student motivation, and manipulation of student interest was considered as a way to achieve this. According to Mitchell (1993), interest is categorized into two groups, personal and situational. While personal interest covers individual-specific interests, situational interest refers to a person's reaction to their surroundings. Attracting students' attention and stimulating them in the moment is based on teachers' ability to catch students' interest with temporary environmental features (Mitchell, 1993). In the current study, teachers explained their practices that they caught learners' attention by integrating technology as a novel activity in their classroom routines. When students' attention is attracted, holding their interest throughout the lesson becomes important. Mitchell (1993) suggested to make the lesson content meaningful, relevant, and significant for holding students' interest. The related actions for holding students' interest enhance long-lasting motivation by accommodating educational goals and individual goals (Bolkan & Griffin, 2018). Based on the findings, whereas teachers integrated technology with teacher-centered activities and benefited from its positive effect on students' attention and motivation, teachers did not mention the features of technology-integrated lessons such as meaningfulness, relevancy and significancy for students regarding their attention and motivation. Hence, this online CoP about integrating cognitive tools might create a chance to observe an example for holding students' interest by providing meaningful, relevant, and significant problem to solve in constructivist learning environments with the help of a cognitive tool.

Another benefit extracted from the findings is *increasing efficiency*. Teachers underlined the role of technology integration in increasing efficiency by stating how assessment applications helped them see students' understanding and provide feedback easily and how using PowerPoint presentations and applications of course books helped them not spend time for writing questions and gain more time for problem solving activities in class time. These integration practices support the role of teacher in traditional classes. These practices have often considered as effective and efficient due to the fact that they save time and costs by teachers (Cheng, Lu, Xie & Vongkulluksn, 2020). This aligns with the findings of this study indicating that teachers considered technology integration beneficial for increasing efficiency.

The findings also indicated that another benefit of technology integration was *resources*. The teachers noted that they used various resources from the internet and combined them based on their classes' needs while preparing their lesson plans. Similarly, a study conducted in England showed that mathematic teachers frequently used computer assisted instruction software such as websites providing teachers lesson plans, homework and various resources (Bretscher, 2014).

Other benefit of technology integration was stated as *helping cognitive processes*. According to the literature, when teachers believe technology is useful in the classroom, they are more inclined to integrate it to help students learn (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010). The findings of the current study revealed that participants found technology useful in students' cognitive processes. Hence, they benefit from technology to help students learn. However, their technology integration practices were limited with facilitating instruction activities such as instructional delivery, drill and practice, integrating videos, visualization and simulation with a teacher centered approach. Supporting students' cognitive processes by positioning students learn with technology is missing in their ICT integration practices. Hence, the implementation of online CoP might create a chance to learn positioning technology as a learning-with medium in students' learning processes.

Another finding related to benefits of technology integration is *learning from technology*. Accordingly, one of the participants stated that technology-integrated classes help students learn from technology as a life-long learning skill. This finding is compatible with the fact that teachers adopt technology as learn-from medium. Although it gains students life-long learning skills, it is known that learning from technology approach does not help students' achievement (Cuban, 2001; Kim & Reeves, 2007; Tamim, Bernard, Borokhovski, Abrami & Schmid, 2011). In this regard, the participation in online CoP about integrating cognitive tools can gain teachers a new perspective for technology integration, learning with technology.

Along with the benefits of integrating technology, the findings of the current study revealed that teachers stated their *willingness* to integrate technology into their practices while stating their opinions about technology integration. Since the teachers make the decision to integrate technology in their practices (Agyei & Voogt, 2010; Christensen, 2002), their willingness can be considered as a positive attitude which is stated as essential in technology integration by Christensen (2002).

It is known that teachers are more likely to successfully incorporate technology into their classrooms if they believe it to be beneficial to the teaching and learning process (Chiu, 2022a). This study showed that teachers mentioned their *positive opinions* about using technology in mathematics classes such as considering technology integration as a necessity to support learning. With a similar approach linking positive opinions with successful integration of ICT, the findings indicating teachers' positive opinions related to technology integration can be considered a supporting factor for learning to integrate cognitive tools and placing them into their future technology integration practices. On the other hand, one of the teachers highlighted that technology integration had no negative aspects whenever it was used by the teachers. This approach reveals the teacher's pedagogical beliefs. Similarly, Tondeur and his colleagues (2017) stated that either teacher-centered or student-centered learning was facilitated by teachers' educational views. In this regard, it can be said that this teacher might have a teacher-centered approach while incorporating technology in mathematics classes. Similarly, the emphasis of the right amount of technology integration and the supportive role of technology in classroom can be associated with teacher-centered approaches.

The findings also indicated teachers' *negative opinions* about technology integration. Teachers stated three aspects; the incompatibility of mathematics instruction with technology integration, the inducement of technology to easy results, and lack of student awareness in using technology for learning. Considering mathematics lesson as incompatible with technology integration can also be associated with teacher' pedagogical beliefs and lack of knowledge and skills about how to integrate technology to support students' understanding in mathematics. Teachers may prefer traditional approaches in mathematics classes with an emphasis on formal and abstract mathematics as stated by some researchers (Maaß & Artigue, 2013; Ozdamli, Karabey & Nizamoglu, 2013). Previous findings also indicated that mathematics teachers were unable to create engaging technology-based mathematics activities because they lacked training in the subject even though they agreed on the cognitive and affective benefits in increasing students' understanding in mathematical concepts (Washira & Keengwe, 2011). Hence, the thoughts about mathematics instruction including pedagogical beliefs and lack of knowledge and skills about how to integrate technology to support students' learning could create a negative opinion about technology integration. In turn, these negative attitudes could lead to teachers' low level of technology integration (Bozkurt & Johnston-Wilder, 2011).

Since students regarded technology as a way of entertainment, they distracted by other options without focusing on their learning. Other research also indicated this distraction of students by gaming and chatting opportunities during computer-based lessons (Storz & Hoffman, 2013). Based on the fact that technology is under-utilized in math classes as shown by many studies (Becker & Ravitz, 2001; Conlon & Simpson, 2003; Cuban, 2001), it can be said that students are not used to learn with technology. As a result, students may not benefit from technology-integrated classes during their learning processes. This unfamiliarity to technology integrated classes can also cause teachers' negative opinions related to the inducement of technology to easy results. In a traditional setting, students are shown the solution of the problems with just one click during the instructional delivery. Since the teacher needs to solve and explain the problem, they may lose their motivation and want to skip the thinking process of the problem by asking teacher to show the solution. Hence, the teachers' negative opinions related to the inducement of technology to easy results can be related to students' lack of motivation and teacher-centered technology integration practices.

The relevant literature suggests that modeling is a good strategy to modify instructors' negative beliefs about technology, broaden their present understanding of technology integration, and foster a tech-friendly culture (Ertmer, 1999, 2005; Glazer, Hannafin & Song, 2005; Vanatta & Fordham, 2004). This online CoP about integration of cognitive tools might have an effect on teachers' negative opinions by providing a mental model for technology use for students' learning in a constructivist environment.

The term utility-value refers to the extent to which teachers believe employing and/or integrating technologies into their lesson plans has an added benefit and is, therefore, beneficial for their lesson plans (Backfisch, Scherer, Siddiq, Lachner, & Scheiter, 2021). Research indicated that higher utility-value levels might encourage teachers to incorporate technology into their lessons more frequently (Backfisch et al., 2020; Scherer et al, 2015; Wozney et al., 2006). Although many studies revealed teachers' willingness to integrate technology into their practices before the pandemic (Arslan & Şendurur, 2017; Kafyulilo, Fisser, Voogt, 2016), the pandemic forced teachers to integrate technology into their classes in a short time with various tools. With this emergency remote learning period, teachers experienced various tools to integrate their classes. Regarding utility-value, the findings of this study indicated that teachers started to *question the role of technology* in their mathematics classes by searching for what could be done to support students' learning and how students can learn with technology and evaluating what the value of their current technology integration practices is. This questioning can be considered as a step for positioning technology as cognitive tools to support learning in constructivist learning environments.

Before the implementation of online CoP, teachers were also asked about their *opinions about cognitive tools*. Although participants had no prior knowledge about cognitive tools in mathematics, they shared their willingness to learn different ways to plan technology integrated practices with various reasons such as integrating different tools, helping students' cognitive processes, motivating students to learn, attracting their attention, increasing efficiency, helping students learning with technology and from technology. Despite the variety of reasons to learn integrating cognitive tools, their willingness to learn a different way of integration can be associated with higher utility-value levels. They may have an expectation about incorporating technology into their practices by benefiting more in teaching and learning processes.

Challenges

The findings of the study indicated the challenges that teachers encountered while integrating technology as ICT competencies, emergency remote learning, time, distraction of students, and assessment (See Table 4.1.3.). These findings are similar to the findings of the related studies. As cited by Stein, Gurevich, and Gorev (2020), numerous studies noted main barriers in technology integration such as lack of resources, lack of knowledge and skills, institutional barriers, assessment related barriers, subject culture and attitudes and beliefs (Buabeng-Andoh, 2012; Çakir & Yildirim, 2009; Desimone et al, 2013; Ertmer & Ottenbreit-Leftwich, 2010; Goktas et al, 2013; Groff & Mouza, 2008; Hew & Brush, 2007; Keengwe et al, 2008; Kopcha, 2012; Mukama & Andersson, 2008; Pierce & Ball, 2009; Reid, 2014).

Regarding *ICT competencies*, teachers' competencies, technical problems, students' competencies, and collaborating with teachers were extracted from the interviews. The participants considered teachers' competencies as a challenge for technology integration practices in this study. Similarly, teachers' competencies in technology skills are highlighted as a barrier for technology integration by many studies (Hughes, 2005; Koehler & Mishra, 2005, Hechter &Vermette, 2013, Hew & Brush, 2007; Inan & Lowther, 2010a; Kopcha, 2012). The finding of technical problems as one of the ICT related challenges for teachers while integrating technology is congruent with the previous research that indicates technical support as an external factor influencing the success of integration (Chiu, 2017; Cheng et al., 2020).

Collaborating with both ICT and mathematics teachers was stated as a need for technology integration and its deficiency was considered as a challenge while integrating technology. While a recent study highlights the role of school learning support including leader, expert, and peer support in encouraging and sustaining technology integration practices (Chiu, 2022a), the participants in this study also mentioned the need of collaborating with other teachers while integrating technology. Regarding this need, another research suggested to create small-group professional learning communities and make teachers support each other while learning the use of various technological tools as a strategy to lessen teachers' anxiety and lack of confidence in technology (Washira & Keengwe, 2011). Hence, the findings from the interviews conducted before the teachers' participation in the online CoP emphasize that the teacher professional development program in this study might contribute their use of technological tools by providing the required collaboration environment with ICT and mathematics teachers.

As well as teachers' competencies, students' competencies were also underlined by the participants as a challenge related to ICT competencies in the technology integration process. Teachers mentioned that students should also have the required skills to use the technological tool during their learning process. Although students are assumed that they have tendency to use ICT tools, they may need some skills to learn with technological tools. This finding is supported by Desimone's study (2009) which stated that utilizing different technology tools and understanding how to use them has become a genuine problem for both students and teachers.

Other challenges that teachers encountered during technology integration are combined under the theme of *emergency remote learning*. During the remote learning period because of the COVID-19 pandemic, teachers experienced technology integration in a remote learning environment and shared their challenges as screen time, difficulty of classroom management, decrease in motivation, decrease in communication, challenge of learning the tools, and difficulty of mathematics instruction. The participants highlighted the long duration of screen time for both themselves and students as a challenge during emergency remote learning. They stated its negative effect on their physical and psychological well-being. While difficulty of classroom management can be related to remote learning environments' dynamics and the lack knowledge and skills of teachers in this area, it can also be associated with students' motivation. A recent study in this issue revealed that teachers had troubles motivating students through computer screens (Reich et al., 2020) which supported the finding of the decrease in motivation. The same study also indicated that emergency remote learning period caused professional loss and burnout for teachers by influencing teachers' self-efficacy and professional identity. The findings of the current study also corroborated that teachers had struggles to learn the tools to continue their teaching remotely and teach mathematics content remotely as well as they did to communicate with students effectively, maintain classroom management and motivate students. Related to decrease in communication, teachers stated that communicating with students, following their understanding and providing support were difficult in remote learning environments. Similarly, Radha and her colleagues (2020) highlighted the effect of this decrease in communication that a lack of extrinsic reinforcements, teacher guidance and peer support affected students' self-regulation of their learning activities.

In this study, another challenge stated by the teachers was *time* while integrating technology. Teachers needed more time for preparing and implementing technology-integrated lessons and learn technological tools. In order to design lesson plans integrating technology and learn the technological tools that can be incorporated, teachers needed time. This finding is supported by relevant research revealing that lack of time is a barrier for teachers' technology integration practices (Butzin, 2001, Cuban, Kirkpatrick, & Peck, 2001; Karagiorgi, 2005; O'Mahony, 2003). For the implementation of lessons incorporating ICT, teachers stated the need for allocating longer time periods for a topic as they did with a traditional approach. Curriculum load creates a time pressure at this point. While teachers work in an environment encouraging to cover all the topics in the curriculum and help students score in traditional examinations, they do not decide to allocate more time for ICT-integrated lessons. Stein, Gurevich and Gorev (2020) also mentioned these main barriers in technology integration as the conflict between the necessity to adhere to the external standards of traditional assessment while embracing technology to improve learning (assessment) and the conflict between the adoption of technology and the norms, practices, and expectations of a subject or school culture (subject culture) by summarizing the related literature. More time for implementation can also be associated with teachers' classroom management skills in ICT-integrated classes. Previous research also supported this by revealing that deficiencies in classroom management skills in technology-integrated environments inhibited ICT integration (Lim et al., 2003; Newhouse, 2001).

Another challenge stated by the teachers in this study was *distraction of students* in technology-integrated lessons. This is in line with the findings of the previous study conducted in higher education indicating that students engaged with technology in a negative way such as distracting their focus (Selwyn, 2016). This could be associated with lack of designing engaging lesson plans that motivates students and positioning technology as learn-with medium in lesson plans. In addition, teachers' lack of classroom management skills in technology enhanced learning environments might cause distraction of students. Professional development about both integrating technology and classroom management in ICT-integrated lessons can help overcome this problem.

During teaching and learning process, teachers benefit from formative assessment to provide students feedback on their performance to improve and accelerate their learning as defined by Sadler (1998). In this regard, technological tools help teachers assess students' understanding easily and provide feedback throughout their classes. The findings of the current study revealed that students' perception of technological tools created an obstacle in *assessment*. Since students considered the ICT-integrated assessment practices as games, they were not interested in answering the questions properly and listening the feedback given by the teacher actively. This perception prevented teachers' integration of technology in assessment activities because they did not achieve their purpose which was assessing students' understanding correctly and providing feedback. To help students improve their learning with the help of the feedback, the previous literature suggested that students should be trained by showing how to understand feedback, relate it to the qualities of the work they generate, and figure out how to move forward with improving their work (Hung, Lin, & Hwan, 2010). Another aspect that is stated by the participants is the result-oriented approach of the ICT-integrated assessment activities. Since the teachers used technology to assess students' learning with the multiple-choice questions, the results did not provide too much information about students' thinking process and it affected the quality of the feedback that teachers could provide. This challenge can be associated with teachers' lack of knowledge and skills for alternative technology-integrated assessment strategies.

Teachers' experiences

The findings of the interviews conducted before the implementation of online CoP revealed teachers' experiences in technology integration practices in terms of their *perceived level of technology integration* and *approaches to mathematics instruction*.

For the perceived level of technology integration, teachers noted that they barely incorporated technology into their classes before the pandemic. This low-level of integration can be associated with both external and internal factors affecting technology integration (Cheng, et al., 2020; Ertmer, 1999; Hurr, Shannon, & Wolf, 2016). While external variables contained technical assistance, principal support, administrative support, and the available resources (Chiu, 2017; Cheng, et al., 2020), teachers' attitudes, interest in integrating technology into their practices, anxiety about new technology were compiled as internal variables (Chiu & Churchill, 2016; Hsu, 2016). All these variables could affect their technology integration into mathematics classes. As stated by Chiu (2022b), the pandemic underlined the significance of technology integration in education, particularly student-centered ICT integration practices.

Regarding their approaches to mathematics instruction, they stated their pedagogical orientation and how they maintain their instruction in classes. Accordingly, teachers highlighted teacher-centered approach in mathematics classes by following traditional approach. Research on mathematics education noted that the integration of ICT is clearly influenced by teachers' pedagogic perspective (Stein, Remillard, & Smith, 2007). Hence, teachers' practices in mathematics classes can be associated with their ICT integration practices. On the other hand, some of the teachers stated that they preferred student-centered approach in their classes. Although the findings indicated low-level technology integration practices with teacher-centered approaches, they considered their pedagogical approaches as student-centered. This contradiction can be explained by the early studies indicating that indicated that teachers' actual beliefs, as shown by their use of technology in the classroom, frequently did not coincide with their stated opinions (Berg et al., 1998; Ertmer, Gopalakrishnan, & Ross, 2001). Recent research also found the similar finding that teachers frequently use teacher-centered software while adopting a more student-centered approach towards mathematics instruction (Bretscher, 2021). This incompatibility was considered as a result of extrinsic restrictions or obstacles imposed on educators by predetermined curricular or assessment procedures (Ertmer et al., 2001). Moreover, only one of the participants stated the lack of knowledge and skills to teach mathematics in a different way from traditional methods by underlining the teacher education programs. In line with the related literature, the limited opportunities that pre-service teachers have related to technology integration can be associated with their limited integration practices as beginning teachers (Tonduer et al, 2016).

Regarding all the findings related to the opinions of teachers related to technology integration before the implementation of online CoP, it can be concluded that teachers' technology integration practices containing activities to facilitate instruction, increase motivation, and assess students' understanding were teacher centered. The learning-with technology approach is missing. Although they find that integrating technology into mathematics classes is beneficial and they stated their willingness to incorporate technology, which could be critical for their future implementations and participation in the online CoP, some of them had negative opinions. Moreover, with the increased use of technology in emergency remote learning period, some of them stated their questioning about the role of technology. At this point, participating in the online CoP about integrating cognitive tools might lead them to consider the role of learning-with technology approach in mathematics, experience student-centered integration practices by comparing with their existing practices, and observe the effects of constructivist learning environments through implementations.

5.1.2 The Effect of Online CoP about Integration of Technology as Cognitive Tools

5.1.2.1 The Knowledge Construction Levels in Online Discussions During the Implementation of Online CoP

During the implementation of online CoP, teachers involved in discussion activities within their small groups and large group. While small group activities included examining sample lesson plans integrating cognitive tools and opinions related to the implementation of lesson plans designed by their small groups, the large group activity focused on examining other groups' lesson plans.

Small group activities

The results indicated that while examining sample lesson plans and discussing their implementation experiences, most of the discussion messages were analyzed within the first phase of knowledge construction which is *sharing/comparing of information*. While both discussion activities mostly included teachers' identification and statement of areas that they disagree in the second phase which is *the discovery and exploration of dissonance or inconsistency among ideas, concepts, or statements*, teachers barely asked and answered questions in these two phases throughout discussion activities. The findings also indicated that there were no discussion messages analyzed within third and fourth phases, which are *negotiation* *of meaning/co-construction of knowledge* and *testing and modification of proposed synthesis or co-construction*.

This distribution among knowledge construction levels might be explained with the nature of the discussion activities. Discussion activities for examining sample lesson plans focused on the use of the constructivist learning environments model, what they find effective, and what they would design differently. While discussing their experiences after the implementation of the lesson plans that they designed, teachers focused on their observations and what they would change if they implemented the same lesson plan. Hence, their discussion within these activities can be based on *sharing and comparing information* and *discovery and exploration of dissonance or inconsistency*. Although they were asked to discuss the points they agreed or disagreed with other participants, these activities may not lead them to negotiate meaning, co-construct knowledge, test and modify proposed synthesis or co-construction. Lucas, Gunawardena, and Moreira (2014) also discussed the effect of nature of discussion activities on knowledge construction. Accordingly, if the discussion requires participants to argue what they have read on a specified topic or to mention their practices, it will lead to the lower phases in knowledge construction. Other studies corroborated this argument (Wang, Woo, & Zoo, 2009; Heo, Lim, & Kim, 2010; Lucas & Moreira, 2010).

On the other hand, the process of designing lesson plans within the small groups is expected to lead teachers to higher knowledge construction levels such as negotiating meaning and co-constructing knowledge as it was mentioned that solving a problem might create more chances for higher knowledge construction phases (Lucas, Gunawardena, & Moreira, 2014). Creating a solution for students' learning with cognitive tools, teachers discussed how to apply the principles of constructivist learning environments and position the cognitive tool in the learning process within the lesson plans. However, in this study, this process was maintained by online synchronous meetings. Hence, if the discussions related to the design of lesson plans were recorded, the knowledge construction levels in higher phases might have been observed. Supporting this, teachers also stated their negotiation of meaning and co-

construction knowledge processes during collaboratively working on designing lesson plans within the interviews.

Moreover, the implementation of the co-constructed lesson plans and discussing what worked and did not work in class were expected to allow them to test their co-construction. However, the discussion activities based on the experiences related to the implementation did not contain any discussion messages in the fourth phase, *testing and modification of proposed synthesis or co-construction*. On the other hand, the interviews indicated their testing against personal experience of technology integration. Some of the teachers shared their changes in their opinions by comparing their teacher-centered approaches in technology integration with the new approach integrating technology as cognitive tools. As it was stated by other studies, the discussion of the implementations led them to decide whether to integrate the new approach in class or not (Chen et al, 2009; Kent, Laslo & Rafaeli, 2016). At the end of the program, teachers stated their willingness to incorporate cognitive tools in the interviews. Hence, it can be deduced that teachers may have tested the new approach against their existing practices and construct their understanding of constructivist learning environments internally but the novelty of participating in an online discussion might limit their discussion of co-construction of knowledge.

The discussion activities within small groups revealed that teachers' messages within the fifth phase, *agreement statement(s)/application of newly constructed meaning*, included only summarization of agreements. Since each small group assigned a reporter role to one of its members and made that member responsible for summarizing the discussion activity, the discussion messages included this knowledge construction level. This was in line with the previous the research suggesting that assigning summarizing roles or tasks throughout discussion activities can help teachers involve in more higher phases (Wise & Chiu, 2011). However, teachers considered that the assigned roles were not performed adequately. Hence, the roles may not have guided them to be involved in higher knowledge construction levels. Although discussion activities did not indicate other two knowledge construction levels (application of new knowledge, metacognitive statement of changes in knowledge or ways of thinking), the interviews showed teachers' metacognitive statements illustrating their understanding that their cognitive schema have changed. Some of the teachers who had negative opinions about technology integration before the implementation of online CoP shared how their opinions had changed with the participation at the final interviews with the awareness of change in their perspectives.

Regarding these findings, as well as the nature of discussion activities within small groups leading teachers to *share and compare information*, and *discover and explore dissonance or inconsistency*, the novelty of participating in an online CoP might affect their knowledge construction levels. The interviews also indicated teachers' hesitations to interact because of novelty of participating in an online CoP and novelty of people within the groups. Moreover, the results indicated that knowledge construction levels in Phase II was less frequent than these levels in Phase I. This means that teachers stated their opinions and shared their agreements more than they stated dissonance. This finding was corroborated with the results of another study looking for how students perceive asynchronous discussions revealing that students had tendency to avoid "challenge and explain cycles" in which they were required to do more than share and compare their opinions in delicate ways (Biesenbach-Lucas, 2003). In addition, cultural factors were also considered as hindering for expressing counter ideas and criticizing others' ideas (Gunawardena & Jayatilleke, 2014). The lack of asking and answering questions to clarify details of the statements and the source and extent of disagreement levels can also be associated with novelty of people within the group. Because of that, teachers may prefer stating their opinions, agreements or disagreements without further asking questions and negotiating meaning. In line with this, it is also known that when unpleasant emotions or words are used during arguments, group members are less motivated to complete their activities and often perform less well (Kirschner & Erkens, 2013). Furthermore, another study revealed that whereas conflict and controversy can affect the few who enjoy it to participate more, they may prevent most of members who don't like it when online conversation turns into a heated debate from participating

(Mompoint-Gaillard et al., 2022). So, they might avoid these situations without involving conflict which is required for knowledge construction. Hence, preparing participants to involve in knowledge construction within online discussions regarding the significance of transitioning from conflict or dispute to ‘constructive controversy’ (Johnson & Johnson, 2009), and then to convergence and structuration (Locke, 2016; Locke & Daly, 2007) can be considered in the design process of online CoPs.

Considering teachers’ lack of experience in online discussions, scaffolding them through discussion activities might be a solution for guiding them to work towards a common goal as a group (Wallen & Tormey, 2019). In this study, although the assigned leader role is expected to encourage other participants to participate in discussions, this role could not be maintained effectively according to the interviews. Furthermore, teachers can be informed about how they can participate to construct knowledge collaboratively before the implementation of online CoP, which was also highlighted in the interviews as orientation of the roles to maintain online CoP. Both the assigned roles such as leader and the participant role can be considered for knowledge construction skills. The need for orientation was supported by another research suggesting that it should not be assumed the participants have the necessary skills to construct knowledge effectively (Tan, Chai, & Hong, 2008). Similarly, Lucas and her colleagues (2014) discussed that the accumulation of knowledge construction levels in the level of sharing and comparing may be related to the instructional design of activities, facilitation strategies used by assigned roles, and participants’ knowledge construction skills.

Large group activity

The discussion activity at the end of the program aimed to share the lesson plans across groups and examine other groups’ lesson plans and their observations within the large group. Each group shared their lesson plans and explained their experiences related to the implementations with a synchronous session. After that, teachers choose two lesson plans and shared their opinions related to the lesson plans by discussing the role of cognitive tool, the use of constructivist learning environments model, and the points they would like to add or change. So, the nature of this large discussion activity might limit teachers' discussions mostly in the first phase, which is sharing and comparing information as it was stated by Lucas and colleagues (2014). For the second phase, discovery and exploration of dissonance or inconsistency, there were discussion messages only indicating the knowledge construction level which is identifying and stating areas of disagreement. Similar to the findings of the small group activities, teachers did not ask any questions in the large group activity. However, this finding can also be related to the synchronous session held before the online discussion. In this session, teachers listened other groups' experiences from their reporter roles and asked their questions. If these sessions were recorded, there could have been discussion messages identifying and stating areas of disagreement.

In conclusion, the related literature and the findings from the online discussion data indicated that teachers were mainly involved in sharing and comparing information. The other phase observed in discussion activities is discovery and exploration of dissonance or inconsistency. The nature of discussion activities maintained asynchronously might be considered for these lower levels of knowledge construction. Moreover, the novelty of participating in an online CoP and participants within the group may have an effect on knowledge construction. Since the assigned roles were not performed adequately, especially the leader roles, they could not guide discussion to higher knowledge construction levels. In order to make the participants involve in higher knowledge construction levels, the orientation of how to participate in an online CoP to construct knowledge collaboratively and how the assigned roles can guide discussions might be considered. Furthermore, this study did not record the synchronous sessions in which teachers maintained their design process of the lesson plans. The analysis of all discussions held synchronously and asynchronously might give a full understanding of knowledge construction within the online CoP. The interviews also supported this by highlighting the collaboration, co-construction of knowledge, and application of the newly learned knowledge while designing lesson plans.

5.1.2.2 The Indicators of Technology Integration as Cognitive Tools in the Lesson Plans

In this study, teachers designed their lesson plans integrating Excel and Scratch as cognitive tools collaboratively by participating in the online CoP. Jonassen's Constructivist Learning Environments Model (1999) was used as a basis within the online CoP. Hence, the products that teachers produced were analyzed based on its components.

Problem

Regarding constructivism and constructionism as a foundation for constructivist learning environments, centering a real-world problem in the center of the model is closely associated with problem-based learning, in which learners are asked to collaboratively work on a problem to produce a solution relating with their existing knowledge and gathering new knowledge with the support of the teacher (Moallem, 2019). Accordingly, the analysis of the lesson plans indicated that all the lesson plans centered a problem which students attempt to solve. As problem-based learning model suggested, the learning activities positioned students as active participants by making them responsible in their learning processes (Hmelo-Silver, 2004; Kuvac & Koc, 2019). Teachers also emphasized the active participation of students while mentioning their opinions related to the effect of constructivist learning environments on students' learning processes within the interviews. In the lesson plans teachers designed, there were tasks that enable learners construct a product, manipulate parameters and make decisions accordingly. This finding was also supported by the interviews highlighting the role of constructionism in students' learning.

The problem situations were designed based on authentic tasks replicating the particular activity structures of a context. Each context was given with a story. All the problems were represented in an interesting, engaging, and appealing way. These findings from the lesson plans are in line with the findings from the interviews indicating the role of integration of mathematics and daily life in students' learning. Moreover, teachers observed that the attention and motivation of students also increased because they find the problems relevant and authentic. This was corroborated with Mitchell's (1993) suggestion for holding students' interest through meaningful, relevant, and significant content. Similarly, problem-based learning highlights the role of real-world event in the presentation of a problem, then students continue to work on the solution through both collaborative learning and self-directed learning (Schmidt, Rotgans, & Yew, 2019).

These problems within the lesson plans were ill-defined or ill-structured problems within a given particular context. In each problem scenario, students were expected to think about the problem and its solution ways without following a routine procedure. If they were well-structured problems, the solutions should have been application of limited number of rules and principles and the problem statement should have contained the parameters of the problem (Jonassen, 1997). Moreover, the lesson plans integrating Scratch as cognitive tools focused on designing and developing a game by programming. In these design problems, students were expected to define the problem, develop solutions, select, implement, and evaluate the solution, following the problem-solving strategies as suggested by McCormick (1998). Accordingly, these strategies are considered similar to the design strategies. Furthermore, design problems are stated as the most complex and ill-structured problems by Jonassen (2004). Hence, these lesson plans included ill-structured problems requiring students to design a game by programming.

Considering the role of ill-structured problems in students' learning, the lesson plans indicated that these problems allowed students to make generalizations and reach the rules by experimenting and reflecting. The interviews also supported this role of students in their understanding by highlighting constructionism within the activities that students involved. The related literature stated that non-routine ill-structured problems improve student learning since addressing them leads students to reach a variety of conclusions through active inquiry, allowing them to use higher-order thinking (Charles & Lester, 1982; Holmes, 1995; Jonassen, 1997). Additionally, Araiku, Parta, and Rahardjo (2019) noted that solving ill-structured problems repeatedly can help learners frame questions, create answers, or come to logical conclusions based on relevant data. Teachers also supported these findings by emphasizing the contribution of cognitive tools in developing thinking skills during the interviews. Supporting this, another study noted that solutions of the ill-structured mathematical problems included different ways and students involved in those solution processes developed their creative thinking skills (Abdillah, Mastuti, & Rahman, 2018).

Related Cases

As Jonassen (1999) stated, one of the components of Constructivist Learning Environments Model is related cases. Accordingly, related cases support learning through scaffolding student memory with the help of case-based reasoning and enhancing cognitive flexibility. The findings indicated that the lesson plans mostly provided related cases to enhance cognitive flexibility, however, any of the lesson plans scaffold student memory through case-based reasoning.

For case-based reasoning, the lesson plans were analyzed whether there was another sample case that helps students solve the given ill-structured problem. Providing different contextual examples that requires similar approaches with cognitive tools allows students to enrich their experience and build a case library (Tawfik & Kolodner, 2016), and this case library leads learners to benefit from these experiences as references and build their understanding and solution strategies based on these cases (Sharma & Land, 2019). In a problem-based learning environment, cases helped students recognize how the variables are used in the given environment, which improves constructing knowledge (Ertmer & Koehler, 2014; Hmelo-Silver, 2013). In this way, student memory is scaffolded to remind a similar case which students can benefit for the solution of the current problem. The findings indicated that the lesson plans did not contain any related cases for case-based reasoning. This might be related to the fact that traditional mathematics classes included well-structured problems. Hence, these past experiences might not represent examples for the solution of the ill-structured problems. On the other hand, the pretraining of the cognitive tools for the readiness of students might have involved similar cases to remind students how to use Excel for formulations or Scratch for programming. In these cases, students might have recalled possible actions that they can benefit during constructing their artifact and solving problem with the help of the cognitive tools.

For enhancing cognitive flexibility, the lesson plans were analyzed to determine whether the activities allow students to identify and apply suitable information, so, comprehend the problem and make decisions (Spiro et al., 1988). The findings revealed that the lesson plans allowed students to recall prerequisite knowledge for both mathematics and ICT. Based on this knowledge, they were expected to understand the case and make decisions to solve the problem. Furthermore, the lesson plans mostly provided related cases to enhance cognitive flexibility by including other contextual examples that requires similar approaches with cognitive tools. Dealing with other problems by adjusting the existing strategies in the new situations help students improve their cognitive flexibility. Moreover, students who had sufficient cognitive flexibility are considered that they cope with novel and challenging situations successfully and generate alternate thoughts and ideas (Stahl & Pry, 2005). This was corroborated with the interview findings revealing that constructivist learning environments helped students develop thinking skills. Similarly, the positive relationship was highlighted between cognitive flexibility and problem-solving skills (Türe & Sarıçam, 2016). Hence, it can be deduced that constructivist learning environments designed by the teachers in this study provided learners opportunities to improve their problem-solving skills as well as cognitive flexibility with the help of related cases while these lesson plans did not provide related cases for case-based reasoning.

On the other hand, although the related cases were highlighted in the model and the lesson plan samples given in the online CoP, in some of the lesson plans, there were not included any related cases. This might be associated with curriculum and time problems as teachers stated as challenges for integrating cognitive tools. Since these lesson plans added to their planning as an extra activity, there were limited time to implement the lesson plans regarding curriculum load. Other issue may be related to extra time for designing and developing. Within the scope of online CoP, teachers struggled to allocate time to design lesson plans. The interviews also revealed this problem for their participation. Hence, these issues may limit their focus on only one problem in the lesson plans. Two of the three lesson plans which did not provide related cases also indicated that similar problems with different contexts were considered but not added into the plan.

Information Resources

The findings indicated that all the lesson plans provided learner-selectable information just-in-time and ensured relevant and accessible information. For the solution of the ill-structured problems in the lesson plans, they need to use their ICT knowledge and mathematical concepts that they have learned previously. As Jonassen (1997) suggested, students use a greater range of conceptual knowledge about the problem domain while solving ill-structured problems. Before the implementation of the lesson plans, prior training sessions were planned for the ICT readiness of students. Moreover, prerequisite objectives were stated in the lesson plans for mathematics readiness. The interviews also indicated the significance of readiness in mathematics and ICT for constructivist learning environments. This finding was also supported by the following statement related to ill-structured problem solving (Jonassen, 1997, p.80):

> “Clearly, better developed domain knowledge (prior knowledge) will enhance problem-solving ability in any particular domain.”

During the implementation, the related information resources were given to the students. Regarding the role of students as active players of their own learning in constructivist learning environments (Xavier et al., 2018), students were expected to use the relevant information sources through their thinking processes. Furthermore, both mathematics and ICT teachers provide required scaffolding through hints to help them solve the problem. Hence, students can access relevant information for the struggles they faced. The related literature about solving ill-structured problems revealed the significance of providing scaffolding to help learners address challenges

(Cho & Jonassen, 2002; Ge & Land, 2004, Jonassen, 2003; Song & Shin, 2010; Araiku et al., 2019). This is also in line with one of the instructional activities, which is scaffolding, that Jonassen suggested for constructivist learning environments (1999).

Cognitive tools

Within the scope of this online CoP, participants were expected to design two lesson plans including Excel and Scratch as cognitive tools. Jonassen (2000) described spreadsheets as cognitive tools that amplify and reorganize mental functioning. Accordingly, while constructing and using a spreadsheet, one is engaged in various mental processes in which he uses existing rules, develops new rules based on the relationships, and organizes information. Moreover, highlighting the potential of spreadsheets in mathematics education, a study argued that mathematics education contained various areas to integrate spreadsheets such as algebraic thinking, multiple representations of concepts, and problem solving (Calder, 2010). For instance, Isiksal and Askar (2005) mentioned the potential of using spreadsheets in encouraging students to involve in deeply thinking and recognizing numerical relationships. In this study, teachers positioned spreadsheets in the lesson plans as a cognitive tool that allows students to organize and represent what they know and scaffold their thinking. While designing and building an artefact, which is the spreadsheet, they negotiate the meaning through the activities and reflected on their discoveries based on the spreadsheet. The contribution of spreadsheets in students' understanding of mathematical concepts were also stated by teachers in the interviews corroborating with the study suggesting learning with cognitive tools to help learners build their own meaning (Tan, 2019). Furthermore, as suggested by Jonassen (2000), the lesson activities included use of the spreadsheet for calculations which offloads cognitive effort related to computations, indicating relationships which is not easy to see without the spreadsheet, and decision making based on the organized information. This is in line with the study discussing that spreadsheets gives chances to learners to use the tool in their learning process to extend their capacity and speed of computation and prioritize mathematical ideas (Calder, 2010).

Similarly, another study noted that the spreadsheets as mindtools decreased the cognitive load of students (Lai & Hwang, 2015). Hence, the spreadsheet was used as a cognitive tool to transcend the limitations of their minds in the lesson plans.

The other cognitive tool used in the lesson plans was Scratch. According to Jonassen and his colleagues (2008), Scratch was the most recent manifestation of constructionism in action in which students create object-based programs and manipulate it by using blocks that help students code. In these lesson plans, students were expected to design and build an artefact by programming it with Scratch. During the design process, students were expected to consider their knowledge in the related domain, organize and represent what they already know in two of the lesson plans. For instance, in one of the lesson plans they needed to design the rounding process of decimals based on digits regarding the procedures in each digit and the expanded form of the decimal. However, in two of the lesson plans, Scratch was not used for organizing and representing what they already know. In these lesson plans, Scratch scaffolded their thinking for the solution of the problem. This difference might be related to the use of cognitive tool for different purposes. Jonassen (2000) stated various purposes for cognitive tools such as cognitive amplification and reorganization and hypothesis testing and mental model building. In these lesson plans, teachers preferred to use the determined cognitive tools to support students' understanding in specific objectives. The purpose of a cognitive tool in class might be organization of information and representation of what they already know or might aim to scaffold their thinking process only.

After developing the related game through Scratch, they negotiated meaning through testing it and made generalizations from their experiments. The activities in the lesson plans scaffolded their thinking with the help of Scratch by involving them in deeper levels of thinking and reasoning such as looking for causal relationships and solving problems. These findings are corroborated with the study indicating Scratch's contribution to the problem-solving skills including goal setting, producing and testing ideas (Taylor, Harlow, & Forret, 2010). In each decision they made throughout the activities, they reflected on what they discovered with the help of the cognitive tool. This is in line with the fact that cognitive tools are used to actively engage students in knowledge construction that reflects their comprehension and conception (Jonassen, 2000). Moreover, Scratch programming activities allowed learners to build their own mathematical understanding as it was suggested to be considered in the design of learning environments (Grover, Pea, & Cooper, 2015; Han, Bae, & Park, 2016).

Regarding the integration of Excel and Scratch into the lesson plans, it can be concluded that teachers involved cognitive tools regarding its functions and the learning objectives. Based on the cognitive tool's features that may help students' understanding and the determined objective, teachers may benefit from cognitive tools in different ways. This finding was also supported by the interviews. The analysis of interviews indicated that teachers highlighted the role of determining appropriate cognitive tools for the learning objectives while integrating cognitive tools. Similarly, in order to engage learners in in-depth learning, interdisciplinary curriculum approaches mention placing appropriate tools that help students' thinking (Chalmers & Nason, 2017).

Conversation/Collaboration Tools

According to Jonassen (1999), constructivist learning environments should include conversation and collaboration tools to create a space for constructing knowledge collaboratively. The findings indicated that the lesson plans designed by teachers included conversation and collaboration tools such as video conferencing tools which also allowed them to group students in separate rooms to work in teams. The implementations during the emergency remote learning period required teachers to design the activities for an online environment. In these constructivist learning environments, teachers played a significant role through helping students co-construct knowledge and engage in productive and in-depth discussions while students were solving the problems (Hmelo-Silver & Barrows, 2006; Ertmer & Glazewski, 2019). Moreover, studies revealed that shifting problem-based learning environments to online environments required teachers adapt their strategies for student collaboration in an online environment (Tsai & Chang, 2013, Lajoie et al., 2014). By means of these implementations, teachers experienced integrating technology for collaboration in mathematics classes. In the interviews conducted before the implementation of online CoP, only one teacher stated the integration of technology for making students collaborate. Hence, experiencing these lesson plans in online environments might have gained them a new perspective for technology integration.

Regarding the design of the lesson plans, it can be said that the activities ensured the collaboration and conversation of learners while working on the problem. The students were expected to collaborate in their decision-making and help each other to build an artefact as it was suggested in constructivist learning environments (Jonassen, 1999). This was also supported by the findings of the interviews noting that collaboration in the constructivist learning environments was considered as a significant factor in students' learning.

Although the conversation and collaboration tools were considered as a solution during the remote learning period in this study, the lesson plans can provide these tools during face-to-face implementations. The activities may be revised for students' collaboration in the class and out of the class by expanding the problem-solving activities to out of the lesson time. Different conversation and collaboration tools might be added to create opportunities for students' collaboration. As well as synchronous online problem-based learning settings, there are also studies discussing asynchronous online problem-based learning environments in which teachers support students' learning processes and collaboration (Lajoie et al., 2014; Chen et al., 2017). Hence, it can be concluded that the collaboration was encouraged in the lesson plans with both the tasks requiring students work on together and the tools allowing them to discuss and co-construct.

Social/Contextual Support

For the social and contextual support, Jonassen (1999) highlighted the role of physical, organizational, and cultural elements of the environment in implementations. In this study, the lesson plans included the preliminary preparations required for the implementation of the lesson plans integrating cognitive tools. For a successful implementation, both students and teachers were required some ICT skills. So, pretraining sessions were planned for students and the mathematics teachers collaborated with ICT teachers. Since the mathematics teachers were not confident in the cognitive tool, the ICT teachers also accompanied during the implementation. Training teachers and students to make sure they can benefit from the cognitive tools in their learning process is also underlined by Jonassen's model (1999). The lesson plans also indicated other considerations such as ensuring students to have the cognitive tool in their computers or ICT lab to be ready for the implementation. Considering whether the implementation takes place in online or face-to-face environment, the required preparations for the learning environment in which students engage with technological tools collaboratively was planned and organized based on available sources (Sullivan et al., 2017).

During the interviews, teachers also stated their competencies, curriculum, preparing students to national exam, limited ICT lesson duration, and workload of ICT teachers as challenges for integrating cognitive tools. All these challenges can be related with social/contextual support. For mathematics teachers' ICT competencies, the organization can plan professional development activities and encourage collaboration with ICT teachers. The organization's approach to learning can support the integration of cognitive tools, even if it takes more time during implementations. Allocating time to teachers for interdisciplinary studies and encouraging these plannings can affect the spread of constructivist learning environments. Hence, the findings from the lesson plans coincide with the findings from the interviews related to the significance of social and contextual support in constructivist learning environments.

Instructional Activities

Based on Jonassen's Constructivist Learning Environments Model (1999), constructivist learning environment should involve learning activities exploration, articulation, and reflection while these learning activities require modeling, coaching, and scaffolding as instructional activities. In this study, the lesson plans indicated that teachers planned activities including problem-solving, question-answer technique, exploration, and collaborative learning.

Although the lesson plans included exploration activities, the lesson plans did not state teachers' modeling activities. Only three of the lesson plans gave place some activities related to modeling performance and articulating reasoning. As the findings indicated teachers did not use any worked examples or similar cases that allows case-based reasoning in the lesson plans, students encountered the problem representation at first. While they were working on the problem, teachers took the role of supporting and facilitating as stated in the lesson plans. These roles of teachers in constructivist learning environments were also stated in the interviews.

Although it was not stated in the lesson plans, modeling activities might have been involved during the implementations. When the students struggled, they might have asked how they can do the required task to the teachers. In these situations, teachers might have modeled the performance or modeled the reasoning. Since the implementations were not observed or recorded, the modeling activities that were stated in the lesson plans were limited. These activities allowed learners to work on the problem first. Before the second activity with a different context that enhances cognitive flexibility, the teacher reviewed the solution of the problem by modeling how to think and perform. This may help them for the solution of the second problem.

Since the lesson plans included question-answer technique as an instructional activity and defined students' learning through problem-solving, exploration, and collaborative learning, it can be deduced that teachers took roles as coaches. They monitored and regulated students' performance, provoked reflection and perturbed their models as stated in the interviews. The lesson activities also included questions to provoke reflection on what they are doing. While working on collaborative tasks, students may need extra support to co-construct their meaning and this support is provided by teachers. The challenges throughout the activities can be handled by students with teachers' inspired guidance (Catlin, 2016). Research on collaborative problem solving also corroborated the coaching role of teachers revealing that giving students additional chances to take part in meta-level reflection exercises together with goal-directed meaning-making activities would help them produce more genuine argumentative discourse (Talaue, Kim, & Aik-Ling, 2015). Since students were not used to be involved in ill-structured problem solving, the struggles may lead them to give up, lose interest, and not to sustain their efforts (Ma & Williams, 2013). Moreover, the findings from interviews supported the coaching role of teachers in students' collaborative discussions while solving problems.

The scaffolding role within these activities might be considered as going along with coaching activities. Through scaffolding, the students are given the opportunity to complete tasks that they are unable to complete on their own, and the teacher is able to gradually reduce the scope and quantity of scaffolding (Cho & Kim, 2020). While visiting the groups and listening their approaches, teachers checked students' progress and provided scaffolding at the right time to lead them to complete their tasks as Üçgül (2012) suggested. This was supported by the interviews. According to the literature, while solving ill-structured problems students need to comprehend the problem correctly, the required help should be provided to the students (Bransford, Brown, & Cocking, 2000). Similarly, during the implementations of the lesson plans, the required scaffolding was provided by the teachers as stated in the interviews. The results of another study revealed that providing scaffolding helped learners to explore the problem situation in more depth while solving an ill-structured problem, in turn, this guided them to focus on finding the best solution (Cho & Kim, 2020).

There were also hints stated in the lesson plans to support students' progress in problem solving. According to the need of the student, teachers could guide them. For identifying teachers' adjusting task difficulty, the design of the lesson activities can also be evaluated. Accordingly, the activities lead them to think the problem-solving process step by step. Moreover, during the implementations, teachers may have provided scaffolding through restructuring the task to supplant knowledge. The lesson plans did not indicate this kind of support overtly, but the interviews revealed such actions as discussed in the role of mathematics teachers in constructivist learning environments.

Other aspect of scaffolding is providing alternative assessments. While some of the lesson plans included some well-structured problems for assessment, most of them required students to send their artifacts at the end of the lessons. Only two of the lesson plans mentioned self-assessment but the details were not stated. One of the teachers also shared her concern about the assessment parts in the interviews as discussed in the integrating cognitive tools section. Since there was limited time for designing a lesson plan integrating a cognitive tool within the context of this online CoP, teachers may not focus on the assessment parts in the lesson plans. Moreover, the planning of these lesson plans was made at the middle of the semester and teachers had already planned their lesson plans and assessment activities based on the curriculum in the interviews. So, these implementations may not be involved in the overall assessment. As Jonassen (1999) stated, the students should be aware of what this complex problem-solving task means and what will be evaluated throughout the problem-solving process to focus their attention, effort, and their strategies to solve the problem. In this way, teachers may scaffold students by providing alternative assessments.

Although there are related statements in the lesson plans related to the instructional activities and supporting quotes from the interviews, observing or recording the implementations might give more details about how teachers facilitated constructivist learning environments. Moreover, the experience of implementing the lesson plans might contribute to improve the first design by adjusting the necessary parts as it was mentioned by one of the teachers while stating her willingness to integrate cognitive tools.

In conclusion, the related literature and the findings from the lesson plans revealed that teachers applied the main principles of constructivist learning environments as Jonassen (1999) suggested. However, the design of the lesson plans was affected by the context of this online CoP. Since the design process was maintained within the semester, teachers may not have focused on including various related cases into the lesson plans that allow case-based reasoning and cognitive flexibility and providing alternative assessments. Including these lesson plans into the yearly-plan might provide them the extra time they need to plan the lesson plans and their social and contextual support mechanisms, consider how to include the assessment of constructivist learning environments within the overall assessment plan. Moreover, modeling as an instructional activity can be highlighted to help novice ill-structured problem solvers since most of the lesson plans did not place any modeling activities in the lesson plans.

5.1.2.3 The Opinions of Teachers on the Impact of Participation in Online CoP on Their Technology Integration Practices as Cognitive Tools

Constructivist Learning Environments

The effect on students' learning

The interviews revealed that teachers observed the effect of constructivist learning environments on students' learning in terms of *learner attention and motivation*, *constructionism, understanding*, *active participation*, *integration of mathematics and daily life*, *integration of mathematics and technology*, *collaboration*, *developing thinking skills*, *easing task*, and *autonomous learners*.

As it was discussed in the initial interviews conducted before the implementation of online CoP, teachers were aware of the positive influence of technology-integrated lessons on students' attention and motivation. However, their implementations were limited with teacher-centered activities. On the other hand, in this study they experienced constructivist learning environments and positioned an authentic problem that students work on at the center of the lessons as Jonassen (1999) suggested. The findings indicated that they all agreed on the effect of constructivist learning environments on *learner attention and motivation*. These lesson plans attracted learners' attention, and motivated them with meaningful, relevant and significant problems throughout the lessons by making students build their knowledge with the help of the cognitive tools. A study also revealed that if students recognize that the subject matter is closely related to their real-life, their motivation is increased to learn that subject matter (Cetin-Dindar, 2016). Hence, the findings are in line with the Mitchell's (1993) suggestion that students' interest can be held by making the lesson content meaningful, relevant, and significant. Considering the fact that mathematics is frequently viewed by middle school pupils as being tedious, pointless, and difficult (Grootenboer & Marshman, 2016) and the possible effect of this perspective on students' mathematics learning, interdisciplinary approaches with real world problems were considered as a way to increase students' interest in mathematics (Stohlmann, 2019). Similarly, this study noted that being involved in constructivist learning environments had a positive impact on students' attention and motivation in mathematics lessons.

Learner attention and motivation in constructivist learning environments might also be associated with these elements observed in this study, *constructionism*, *integration of mathematics and daily life*, *integration of mathematics and technology*, and *collaboration*. Teachers highlighted that students were motivated to produce their own products in an authentic context that highlights the relationship of mathematics and daily life and the role of technology in problem solving. Similarly, problem solving environments including real-world contexts were noted as appealing and motivating for students' working on problems in mathematics (Cheng & Toh, 2015). Since hands-on interactive activities and technology-based mathematics lessons were preferred by middle school students instead of traditional lessons (Raytheon, 2012), integrating cognitive tools in mathematics allowed them to involve in constructionist lessons in which they motivate to learn and actively participate.

Whereas interdisciplinary problem-based learning approaches in science, mathematics, engineering, and mathematics have been emphasized recently, integration of mathematics and technology for students' understanding was stated as an area that needs further attention (Stohlmann, 2018). In this regard, this study propounds that by integrating cognitive tools in mathematics lessons, students were involved in activities *integrating mathematics and technology* and positioned technology as a learning partner while dealing with an authentic problem. Integration of mathematics and technology in constructivist learning environments provided learners connected, focused, meaningful, and relevant learning experiences as it was intended by interdisciplinary curriculums (Smith, & Karr-Kidwell, 2000). Ill-structured problems within a real-life context give students chance to realize *integration of mathematics and daily life*.

These results can also be explained with situated learning theory. Lave and Wenger (1991) describes the situated learning theory with the premise that every idea and human activity is a generalization, adjusted to the existing context. Accordingly, the learning occurs through social interaction in an authentic context in which learners participated in a "community of practice" that contains beliefs and behaviors to be achieved (Lave & Wenger, 1991). During the implementation of the lesson plans, the learners worked in groups to solve an authentic problem related with daily life by using a cognitive tool. This collaborative experience simulating a real-world challenge made them involve in situated learning. Teachers observed that students actively participated in these lessons integrating cognitive tools. *Active participation of students* can be considered as a result of learner attention and motivation. The motivated learners were involved in problem solving actively. Moreover, working on a task collaboratively created an enthusiasm to deal with challenges. Collaboration also contributed students' learning by allowing them to develop ideas through interactions in a constructionist environment (Han & Bhattacharya, 2001). Seeing others' ideas and approaches can help learners modify their way of thinking, clarify their predictions, and explain ideas that are not yet completely developed (Hoyles, 1985).

Another aspect discussed in literature related to cognitive tools is its contribution to meaningful learning (Jonassen, 2000). For meaningful learning, learners take an active role by manipulating the objects in the environment and observing its effects, construct their meaning through articulation and reflection, express their intentions related to the decisions they have made, and deal with an authentic problem collaboratively (Jonassen, Peck, & Wilson, 1999). In this study, teachers' observations revealed that integrating cognitive tools in mathematics lessons helped students' *understanding*. With the help of the cognitive tools, students discovered the mathematical relationships easily. This finding was corroborated with the result of an interdisciplinary study incorporating 3D computer-aided design tool to teach volume of solids indicating that integration of mathematics and technology helped students understand mathematical concepts through a real-world based problem (Ng, 2017). Moreover, in some of the lesson plans, cognitive tools eased their task as it was stated in the interviews whereas in some others, students' observations helped them address the common misconceptions in the related topic. As Jonassen (2000, p.10) highlighted, "… learning with mindtools requires learners to think harder about the subject-matter domain being studied than they would have to think without the mindtool." Similarly, previous research on constructionism highlighted that if the digital tools were integrated to address learners' challenges and potential misconceptions on any topic, the tools should help them relate with the subject matter without making it hard for them (Geraniou & Mavrikis, 2015).

Other researchers also explained understanding the content as "matter of being able to think and act creatively and competently with what one knows about the topic" (Perkin & Unger, 1999, p.97). This approach, teaching and learning for understanding, mentioned that students need to be involved in activities that help them construct initial conceptions, engage in explorations, examine and manipulate the objects and then reach deeper understandings (Perkin & Unger, 1999). Similarly, the interviews indicated that students understood the mathematical concepts better through exploring, examining, and manipulating the given problems with the help of cognitive tools. Hence, it can be concluded that integrating cognitive tools contributed students' understanding.

During the learning process, constructivist learning environments provide students manipulation spaces that leads to negotiate and construct meaning. In this study, teachers stated that students were involved in activities that leads them to think through cognitive tools and discover the relationships. The role of constructivist learning environments in developing thinking skills were highlighted in the interviews. This finding corroborated with Jonassen's explanation of cognitive tools in terms of thinking skills (2000). He highlighted that cognitive tools engaged and supported learners for critical, creative, and complex thinking. While critical thinking focuses on reorganizing knowledge in meaningful and useful ways through evaluating, analyzing, and connecting, creative thinking emphasizes generating new knowledge by going beyond the existing knowledge through synthesizing, imagining, and elaborating. On the other hand, complex thinking combines content, critical, and creative thinking through problem solving, designing, and decision making (Jonassen, 2000). Regarding the central position of the problems in the lesson plans, students were involved in problem-solving activities, which is also stated as fostering thinking skills by many studies (Kumar & Refaei 2017; Dabbagh 2019; Wilder 2015).

As it was discussed in the analysis of lesson plans, the lesson plans implemented consisted of ill-structured problems in which students were expected to analyze problems critically, design their artifacts creatively, and decide their actions with reasons throughout the process. During the learning activities, they used their existing knowledge and discovered mathematical relationships by going beyond what they already know with a learning-with technology approach. This is also in line with the study suggesting that technology can be integrated into mathematics lessons where learners engaged in discovery, exploration, and higher-level thinking with interesting and fun real-life applications of mathematics **(**Soucie, Radovic, & Svedrec, 2010). Moreover, integrated science, technology, engineering, and mathematics curriculum approaches highlighted the role of thinking tools (Kokotovich, 2008; Puntambekar & Kolodner, 2005). Accordingly, during such interdisciplinary lessons, external representation generating tools such as concept maps, tables and graphs, tools for indicating various perspectives, and tools for reflection help learners to engage in in-depth learning by improving their thinking skills (Chalmers & Nason, 2017). Hence, it can be said that these lesson plans had an influence students' learning process by supporting their critical, creative, and complex thinking skills while placing cognitive tools in ill-structured problem-solving processes.

One of the teachers highlighted the role of cognitive tools in making students autonomous learners. The literature defined learner autonomy as being able to take on the responsibility of one's own learning (Holec, 1981). In this study, constructivist learning environments led learners to own the given problem situation and look for solution strategies. During problem-solving and creating an artifact, they discovered the mathematical relationships and used their existing knowledge related to the topic. So, learners can be considered more autonomous in their learning by taking responsibility of solving the given problem through experimenting their approach. If their strategy does not work, they tried another one during the implementation of lesson plans integrating cognitive tools. Finally, they reached a conclusion through testing their solution. These actions were corroborated with features of the autonomous learners stating that these learners understand the learning objectives and methods, identify their own goal, select their own strategies, monitor their progress, and construct their own outcome (Dickinson & Wenden, 1995). Similarly, Noss and Hoyles (2017) highlighted the ownership of students in constructing their knowledge. Furthermore, the studies on problem-based learning with an interdisciplinary approach noted that such learning environments contributed to students' autonomous investigation with the help of ill-defined tasks (Slough & Milam, 2013). Although the contribution of constructivist learning environments to autonomy of learners was underlined by only one of the teachers, regarding the related literature and the problem solver role of learners within these lesson plans, it can be concluded that integrating cognitive tools can be helpful for improving students' autonomy during learning processes. Jonassen (2000) also underlined the development of self-regulation skills through the integration of cognitive tools with providing necessary support even if students are not familiar.

Integration of cognitive tools

The interviews revealed teachers' opinions related to integration of cognitive tools based on the experiences during the online CoP. Accordingly, most of the teachers shared their *willingness* to integrate cognitive tools. Moreover, in order to integrate cognitive tools in their practices, they suggested *increasing duration of lessons*, *integrating them to the yearly plan*, *determining appropriate cognitive tools*, and *face to face implementation*. In addition, they stated their *desire to implement peers'* *lesson plans*, *use variety of cognitive tools*, and *share with others* along with suggestions which are *planning with ICT teachers, working with different grades*, *integrating cognitive tools in different subjects*. Finally, one teacher highlighted *assessment* in constructivist learning environment whereas another one suggested to design shorter sample lesson plans integrating cognitive tools.

With a holistic approach, the categories extracted from the interviews revealed that teachers stressed their willingness to integrate cognitive tools in their mathematics lessons. Considering the fact that integrating technology in an authentic and meaningful way requires persistence as well as adoption (Chiu, 2022a), the expression of willingness can be regarded as a sign of autonomous motivation which determines the success of technology integration (Ryan & Deci, 2020). For the future implementations, they would like to increase the duration of lessons and allocate more time for implementation which allows to give more time to students for working on the problem in the lesson plans. Similarly, another research revealed that students needed more time to study on semi open-ended authentic problems in mathematics regarding the tasks requiring more time to be understood in a rich context (Cheng & Toh, 2015). Moreover, unfamiliarity of both students and teachers may require more time for the implementation. Integration of cognitive tools was suggested to be placed in the yearly plan. In turn, teachers may plan their timing throughout the curriculum as well as their preparations for readiness.

Determining appropriate cognitive tools during the planning process was also stressed since it may help to focus teachers' effort for designing a constructivist learning environment on appropriate topics, which students have difficulties to understand. So, the integration of cognitive tools can have a positive effect on students' understanding as in other studies (Peng et al., 2019; Gijler & de Jong, 2013; Wang, Cheng, Chen, Mercer, & Kirschner, 2017; Wang, Wu, Kirschner, & Spector, 2018). Therefore, the matching of appropriate cognitive tool with appropriate topic can be considered as a critical factor for integrating cognitive tools. During the planning process, the significance of involvement of ICT teachers was stated for both identifying the appropriate tool and planning for the readiness of students.

Considering teachers' lack of knowledge about the possible tools that students know or learn throughout their ICT curriculum, collaboration with ICT teachers can support their decision of the cognitive tools to be used.

The findings also indicated that in order to provide the required support during the implementation, teachers suggested to implement the lesson plans integrating cognitive tools in a face-to-face environment. As it was discussed, one of the instructional activities that teachers apply in constructivist learning environments is scaffolding (Jonassen, 1999). Through scaffolding, teachers provide the necessary support to the students to complete their tasks (Cho & Kim, 2020) by monitoring their progress. However, online implementation was stated as a challenge in integrating cognitive tools. Since online learning environment affects communication negatively (Radha et al., 2020), teachers suggested to implement the lesson plans integrating cognitive tools in face-to-face environments by highlighting their role of scaffolding.

Teachers' statement of their desire to implement peers' lesson plans that were produced during the online CoP and share what they have learned with others in their schools supported the finding of their willingness to integrate cognitive tools. Different lesson plans that were created within the online CoP might have provided them broader perspective for their future plannings since these examples showed them how to align these tools with specific objectives in mathematics curriculum (McCulloch, Hollebrands, Lee, Harrison & Mutlu, 2018). Sharing with others in their department could position them as leaders in integrating technology and this collaborative environment might lead to create new lesson plans and provide the necessary support within the school for the integration of cognitive tools. According to Roger's diffusion of innovation approach (2003), they can be role models as early adopters and help others how to incorporate cognitive tools. Moreover, through their knowledge and skills, they can provide mentorship to the other teachers in their department (Smith, 2012). While the program gave them chance to examine different examples integrating Excel and Scratch as cognitive tools, they suggested to learn a variety of cognitive tools during the online CoP since it might help them improve knowledge and skills about integrating cognitive tools. Similarly, working with different grades was stated as a way of improving their perspective.

Based on the experience of designing and implementing lesson plans integrating cognitive tools, one of the teachers considered assessment parts that they designed as inadequate and suggested to reconsider assessment parts including the assessment of product. Although this suggestion was limited, it highlighted the need for assessing students' learning with cognitive tools. The related literature states that learning with cognitive tools should be assessed in terms of knowledge construction, self-regulation, collaboration, critical, creative, and complex thinking (Jonassen, 2000). Accordingly, since assessing learning through these perspectives is difficult, it is suggested to approach assessment with different assumptions and methods, change teachers' authority role by letting students discuss their goals and intentions, self-assess, and involve multiple criteria for the assessment of learning outcomes. The analysis of the lesson plans also revealed that the lesson plans did not provide alternative assessments. This finding can be associated with the limited time for designing lesson plans during the online CoP. Hence, designing lesson plans before the academic year begins might create more time to focus on assessment parts of the lesson plans.

Challenges of integrating cognitive tools

While integrating cognitive tools into their practices, teachers encountered some challenges and stated them as *teachers' competencies*, *online implementation*, *extra time for planning*, *curriculum*, *preparing students to the national exams*, *limited ICT lesson duration*, and *workload of ICT teachers*. These challenges are also in line with the study related to the factors influencing mathematics teachers' use of ICT which highlighted contextual factors at school level such as convenience of time for planning and instruction, culture of the department and school, teacher professional development (Stein, Remillard, & Smith, 2007).

The findings of this study revealed that *teachers' competencies* could be considered as a challenge for integrating cognitive tools. First, ICT skills of teachers were highlighted. Without having the skills to use the selected cognitive tools, teachers cannot design and implement lesson plans. Similarly, it was stated that teachers should know how to use the cognitive tools to facilitate students' use through modeling, coaching, and scaffolding (Jonassen, 2000). On the other hand, the literature also underlined that teachers should gain ICT skills to help students learn with technology rather than to function as the expert of the technology (Jonassen, Howland, Marra, & Crismond, 2008). During the interviews, teachers stated their hesitations related to their ICT skills to integrate them into their practices. Hence, they might be informed that they should not focus on gaining advanced level of knowledge and skills about the cognitive tool they will use, rather they can focus on ICT skills that will help them design lesson plans allowing students to learn with technology. Throughout the process, they can learn the cognitive tool with the students as Jonassen and his colleagues suggested (2008).

The lack of ICT skills was also associated with allocating time for learning the cognitive tools. Since most of the teachers had no prior knowledge in using Scratch, this study planned a training for teachers' ICT competencies during the online CoP. However, within a limited time that they have, learning the tool became a challenge. To address this problem, collaborating with ICT teachers for the selection of appropriate cognitive tools might be considered before the academic year and the required professional development can be planned accordingly. Similarly, a review about interdisciplinary approaches for mathematics teaching revealed that mathematics teachers at middle and high schools collaborated with teachers from other subject areas such as technology in order to eliminate their hesitations during interdisciplinary studies (Stohlmann, 2018). Furthermore, research also corroborated that expert and peer support is critical in maintaining technology integration practices along with leader support (Chiu, 2022a).

Another teacher competency that was underlined in the interviews for the integration of cognitive tools is related to teaching skills within constructivist learning environments. As Jonassen (2000) stated, integrating cognitive tools in classrooms requires teachers to change their roles to "instigator, promoter, coach, helper, model, and guide of knowledge construction" (p. 276). Regarding the teacher-centered approach they adopted in their practices as they stated in the interviews conducted before the implementation of the online CoP, transitioning their role for constructivist learning environments can be challenging since the integration of ICT is clearly influenced by teachers' pedagogic perspective (Stein, Remillard, & Smith, 2007). Moreover, teachers' competencies related to designing bridging activities that unify, reinforce and sustain learners' mathematical way of thinking beyond their involvement in technology were underlined by prior research (Geraniou & Mavrikis, 2015). For instance, a study about integration of Scratch indicated that teachers had a limited understanding of using the tool for cross-curricular activities (Bustillo & Garaizar, 2014). In order to support teachers to gain this perspective, they suggested to provide a set of best practices, learning guides and curriculum models. Hence, regarding the need of gaining teachers necessary skills for converting a computer-based tool into a cognitive tool (Akyol & Sendurur, 2019), both ICT skills and teaching with cognitive tools skills can be considered for the teacher professional development for integrating cognitive tools.

Another challenge was stated as online implementation. Since this online CoP was conducted during the remote learning period because of the pandemic, the lesson plans were implemented in online environments. As it was discussed in the challenges section of the initial interviews, teachers considered that online learning environment created difficulties in classroom management and mathematics instruction, and decreased students' motivation (Reich et al., 2020) and communication (Radha et al, 2020). Hence, trying a new approach in online setting might cause additional challenge for teachers. Moreover, the findings indicated that teacher had struggles in classroom management, students' connection through mobile tools, and the limited lesson durations while implementing the lesson plans integrating cognitive tools online. In addition, in order to provide the required support during the implementation, the lesson plans were suggested to be implemented in a face-to-face environment as discussed in the previous section.

The results indicated that teachers needed more time for planning a lesson plan integrating cognitive tools which can be challenging within the semester. Regarding the integration of cognitive tools within an authentic context, this is in line with the findings of another study stating that planning a lesson plan including real-world problems required more time for teachers (Cheng & Toh, 2015). Along with the design of the lesson plan, extra time for planning students' readiness activities was also stated. Hence, the planning process may require collaborative work with ICT teachers. As it was discussed, planning before the academic year might provide a solution for planning. Moreover, both mathematics teachers and ICT teachers may need time in their schedules during the academic year for collaborative work. This study also revealed that heavy workload of ICT teachers became an obstacle for collaboration. Furthermore, limited ICT lesson duration was stated as challenging for students' readiness. So, the administrative support might be needed to address these challenges. Similarly, Jonassen (2000) suggested interdisciplinary teaching arrangements for effective facilitation of lessons integrating cognitive tools. Moreover, these findings conformed that the wider adoption of constructionism in learning environments of school settings was restrained by the traditional structures of schools as stated by other studies (Jon, 2016; Kafai & Fields, 2018, Thanapornsangsuth, & Holbert, 2020).

The curriculum also limited them because of the need to cover the intensive content load, which is also highlighted as a challenge by other studies (Cheng & Toh, 2015). Because of curriculum load, they may not allocate necessary time for the implementation of such lesson plans. Moreover, the curriculum pressure can be associated with the fact that teachers need to prepare students for national exams, which is another challenge (Fox & Henri, 2005). The exam pressure may influence the school culture in which teachers need to cover the content in the curriculum. Within this kind of school culture, teacher may not allocate time for constructivist learning environments. The external expectations and measures inhibited the adoption of constructionism (Tan & Ong, 2020). Similarly, Noss and his colleagues (2020) discussed the negative effect of high stakes mathematics tests in the implementation of integrated mathematics and programming curriculum with a constructionist approach. Accordingly, the exam pressure leaded teachers to give their time to practice and revision studies. For the application of constructivist learning environments, the administration should also share a perspective for student knowledge construction and critical thinking (Jonassen, 2000) rather than encouraging preparing students for national exams only. When it is needed, flexible scheduling may provide the required blocks of time for students' negotiation and constructing their knowledge with the administration support (Jonassen, 2000).

Readiness of students

The findings indicated that readiness of students was significant for constructivist learning environments. As it was discussed, within the lesson plans, students focused on a problem to solve through designing and building artefacts with cognitive tools. So, the students' ability to use the cognitive tools can be evaluated as significant. Similarly, teachers underlined the ICT readiness of students for constructivist learning environments. Although the cognitive tools were selected based on the tools covered in ICT lessons, some of the students were struggled to use the cognitive tool effectively to solve the given problem in the lesson plans. The findings of another study also highlighted that the lack of knowledge and skills in a required field may create problems while students were engaging in ill-structured problems (Güleç, 2020). Some of the struggles of students related to ICT might be associated with the lack of ICT lessons during the emergency remote learning period. The limited duration of ICT lessons may also create an obstacle for students' ICT readiness.

Moreover, teachers stated the importance of mathematics readiness for constructive learning environments. The analysis of lesson plans also indicated that most of the lesson plans required learners to organize what they already know. The required prerequisite knowledge and skills in mathematics were stated in the lesson plans. So, students could design their artefacts by using their existing mathematical knowledge. Hence, the mathematics readiness is critical for their problem-solving process. Research also noted that regarding students' different levels of prior knowledge and skills, support mechanisms should be planned for integration of cognitive tools to support students' learning (Lai & Hwang, 2015). Planning pretraining sessions to remind students' prerequisite knowledge, modeling of solving a similar problem, or grouping students to provide peer support may be considered as strategies for readiness of students.

Teachers' role in constructivist learning environments

Within constructivist learning environments, teachers experienced that they took roles for supporting students, facilitation, and classroom management. The first role they highlighted is *supporting students*. During the implementations, the necessary support for students was provided by both ICT and mathematics teachers. Since teachers did not feel competent enough to use cognitive tools, ICT teachers' support was planned. On the other hand, they collaborated before the implementation and teachers were aware of the purpose of the cognitive tool and how it would be used in the lesson. Similarly, Jonassen (2000) suggested teachers to understand the cognitive tools and their purposes to be able to model, coach, and scaffold. This collaboration and pre-training about the tool also created social/contextual support for the implementation as suggested in Constructivist Learning Environments Model (Jonassen, 1997). Hence, the environment was planned to support students through modeling, coaching, and scaffolding by ICT and mathematics teachers.

On the other hand, teachers' support role should be implemented carefully regarding constructionism. Students should be involved in an environment that they can collaboratively solve a problem and produce an artifact with guidance (Rob & Rob, 2018). Similarly, within interdisciplinary problem-based learning environments, teachers' support was suggested to strike a balance between helping students grasp fundamental concepts and letting them use what they have learnt in ways they see fit while solving problems (English & King, 2015). Moreover, Foa and his colleagues (1996) underlined the comfort that teachers should have for tolerating students' progressing separately and in their own time while implementing constructivist, project-based or problem-based learning approaches.

While providing support for students, online implementation was considered as a challenge, as it was mentioned previously. It might be associated with the unfamiliarity of teachers' designing collaborative activities in online environments as it was shown in the initial interviews. Moreover, research indicated that teachers needed to adapt their strategies according to online environment to help students collaboratively work on problems (Tsai & Chang, 2013, Lajoie et al., 2014). This novelty of the environment might have an impact on their support strategies.

The second role that teachers mentioned is *facilitation*. In constructivist learning environments, students were dealing with ill-structured problems collaboratively, which can be considered a new approach for students, they followed the activity sheets that guides them through questions. In these environments, teachers listened their problem-solving approach and asked questions to help them progress. Jonassen (2000) described the role of teachers in traditional settings by stating that "Teachers are simply used to showing students how to do things and providing them with the answers they seek" (p. 276). Moreover, studies indicated that teachers had difficulties in implementing constructivist approaches (Uslu, 2017) and integrating technology in student-centered activities (Keleş, Öksüz, & Bahçekapılı, 2013; Türel, 2012). However, constructivist learning environments lead them to allow students to think for themselves without giving the answer. Moreover, there might not be only one correct answer. The findings indicated that teachers discovered that their role was different while integrating cognitive tools. They stated that they had prior knowledge about how teachers should act in a constructivist setting, however, they experienced their role as a guide while students constructing their knowledge and building their artefacts through cognitive tools. It might be said that teacher experienced to relinquish their teacher-centered role in classroom and facilitate student-centered activities with the help of the implementations as the facilitation role of teachers was highlighted in constructionist approaches (Rob & Rob, 2018).

The third role that teachers mentioned is the difficulty of *classroom management* while integrating cognitive tools. It can be explained with the novelty of working in a constructivist learning environment. Since students were not used to take their own responsibility for learning in a student-centered environment, this might be challenging for them. This is in line with the literature stating that “Students do not approach learning mindfully, and few consistently exhibit self-regulation of that learning. Most have never been required to, so they do not know how. Most, if not all, of their learning careers have been directed by teachers, so making the transition to learner control and self-regulation will not be easy for them” (Jonassen, 2000, p. 274). Hence, the difficulty of classroom management may decrease with the increase in practices integrating cognitive tools. As students learn to engage in critical thinking and knowledge construction and regulate their learning process, they might focus on the tasks and embrace their learning goals during the implementations. Moreover, teacher education programs and in-service teacher professional development activities might focus on equipping teachers with classroom management skills for technology-integrated classes regarding differences as discussed by Hew and Brush (2007).

Change in students’ attitudes

The findings of this study revealed that students’ attitudes towards ICT and mathematics were critical factors for implementing constructivist learning environments. Accordingly, if students had positive attitudes towards ICT, they were easily motivated to participate in the lessons integrating cognitive tools. Most of the students were stated as highly motivated in the implementations. On the other hand, if students had negative attitudes towards ICT, they may not be motivated to relate technology and mathematics. Teachers mentioned some of their students that were not participated as others because of lack of their interest or bias related their ICT skills.

Moreover, students’ perspective for technology integration was considered as a significant element. When students relate technology only with games, they may not focus on the learning tasks which affects their participation in the problem-solving process. Hence, the unfamiliarity of students to constructivist learning environments in which they are supposed to collaboratively work on an authentic problem with the help of cognitive tools can also be considered as a challenge since it may affect students' attitudes towards ICT integration in mathematics classes and in turn, their participation and learning. In line with the literature, the students did not know how to approach learning mindfully and regulate their own learning as it was required for constructivist learning environments (Jonassen, 2000). Furthermore, in order to gain positive and confident attitude towards interdisciplinary studies, a recent study revealed that students should be encouraged to participate in interdisciplinary activities containing authentic and student-centered tasks (Ku, Hsu, Chang, & Lin, 2022). So, integrating cognitive tools in the appropriate lessons may help them develop these skills and perceive technology as a learning partner which may affect their attitudes towards ICT.

Another aspect related to the change in students' attitudes was based on students' attitudes towards mathematics. Teachers stated that most of the students considered mathematics as a difficult and unlovable course, and constructivist learning environments gave students chances to experience a student-centered and engaging mathematics lesson. Similarly, Grootenboer and Marchman (2016) mentioned students' views on mathematics as being tedious, pointless, and difficult. On the other hand, interdisciplinary activities which position real-world problems as the center were considered as an element increasing students' interest (Stohlman, 2019). If students find the subject matter relevant in terms of their lives, they motivated to learn that topic (Cetin-Dindar, 2016). Various studies highlighted the positive effects of interdisciplinary approaches such as motivating to learn (Guthrie, Wigfield, & VonSecker, 2000; Stohlmann, Moore, & Roehrig, 2012) and engaging in student-centered learning environment (Struyf et al., 2019). Working on an authentic problem by incorporating technology in constructivist learning environments might influence students' attitudes towards mathematics. In turn, they may participate actively to construct their mathematical knowledge and skills as well as critical, creative and complex thinking skills.

Maintaining Online CoP

Participation of teachers

Within the theme of participation of teachers, teachers shared their opinions related to workload of teachers, active participation of teachers, changes in motivation, instability because of pandemic, time during working hours, willing to attend similar online CoP, delegating the duties, and face-to-face participation to CoP.

While teachers stated that the activities within the online CoP required them to *actively participate* in tasks including collaboration and sharing as different studies highlighted (Moolenaar, Sleegers, & Daly, 2012; Thurlings, Evers, & Vermeulen, 2015), *the workload of teachers* limited their participation. Since teachers were not provided time for professional development during the semester in working hours and they had to deal with changes related to emergency remote learning period as well as their extra tasks, their participation required them to spend their personal time for their professional development. So, the planned schedule for the online CoP could not be followed during the process. This was in line with the study noting that lack of time as a main barrier to participate in an online CoP (Boada, 2022). Although teachers were motivated to learn how to use cognitive tools in their lessons, *the changes in their motivation levels* throughout the process influenced their participation. Moreover, their motivation was affected by *instability because of the pandemic,* the recognition of their effort from their administration, and their observations related to learners' motivation and participation in the implementations. Hence, providing time for professional development activities in teachers' working hours and balancing their workload regarding extraordinary situations like the pandemic might affect their participation in the online CoP positively.

Furthermore, the support from the administration may have an effect on teachers' motivation to participate in professional development activities as Boada (2022) mentioned that since teachers have tendency to prioritize the activities that their administration gives importance the most, their participation in an online CoP which is formally intended to improve their knowledge and skills is affected by administration’s support. The implementation of lesson plans provided teachers to experience constructivist learning environments and teachers observed that students were highly motivated and participated actively during the implementations. So, experiencing the lesson plans integrating cognitive tools and observing their positive effects on students’ motivation and participation may positively affect teachers’ participation. Similarly, previous studies discussed that higher-utility value levels about technology might lead teachers to integrate technology more frequently (Backfisch et al., 2020; Scherer et al, 2015; Wozney et al., 2006). Hence, realization of positive effects may motivate teachers to learn how to integrate cognitive tools and participate in the program.

In addition, as it was seen in online discussions, teachers shared and compared their observations, identified inconsistencies, and agreed on their inferences based on their implementations. Sharing the same experience while learning a new approach for integrating technology might motivate them to participate in the online CoPs. In line with the literature, engaging and participating in a CoP helps participants learn within a social activity (Goodyear & Carvalho, 2014). In line with the literature, regarding the experiencing benefits of the participation in this program, teachers stated their willingness to attend a similar online CoP (Boada, 2022).

While participating in the online CoP, teachers worked in small groups and within each group, there were roles including leader, reporter, and timer to maintain online CoP as it was designed in the professional development program. Although these roles helped to maintain activities, the findings indicated that teachers suggested to *delegate the duties* while the activities related to the design of lesson plans. Accordingly, each member takes the responsibility of some part of the lesson plan, and then they came together, discussed and finalized the lesson plan. This suggestion was made to increase the participation of each member in the online CoP. Since teachers are used to work similarly in their schools, this delegation of duties may affect their participation. This suggestion can also be associated with the time spent for designing lesson plans. Delegating duties, coming together to discuss the parts they worked on individually and finalizing the lesson plan can accelerate the process.

Some of the teachers in this study suggested that face-to-face involvement to the CoP can increase their participation in professional development activities. This might be associated with the unfamiliarity of teachers participating in a professional development program online. In addition, the effort and time they allocated to participate in online activities may not have been considered by their administration. Since in face-to-face participation, their schedule and planning including transportation and accommodation need to be considered. So, face-to-face participation may be recognized more by the administration. Moreover, teachers may easily focus on the professional development activities in the specified time interval. Hence, allocating time in working hours for teachers' participation in online professional development activities and support from the administration may create a difference in their participation and interaction quality.

Interaction between teachers

Interaction is regarded as an essential element in teacher professional development activities (Ernest, Catasús, Hampel, Heiser, Murphy & Stickler, 2013). In online community of practices, teachers are expected to access all members, collaborate, and interact through exchanging information and experiences (Dubé, Bourhis & Jacob, 2005). Similarly, teachers collaborated and interacted through professional development activities during participating in the online CoP.

Regarding *interaction*, the findings from the interviews revealed that most of the teachers considered interaction quality as sufficient whereas some of the teachers thought that it could be better. For the interaction quantity, they were agreed on that it could be increased. These opinions may be associated with the lack of participation time in working hours, workload of teachers, instability because of the pandemic, and the novelty. Moreover, other studies emphasized the difficulty of sustaining a collaborative interaction among teachers (Akiba, Murata, Howard & Wilkinson, 2019; Horn, Garner, Kane & Basel, 2017).

Teachers were not used to discuss their opinions in online discussion environments, so this might affect their interaction. In line with the related literature, the *novelty* of interacting in an online discussion forum can be challenging for teachers (Chen & Chen, 2009; Carr & Chambers, 2006). They may not express themselves comfortably. As well as the novelty of participating in an online CoP, teachers stated that the novelty of the participants. It may also affect the interaction quality. Although online CoP creates networks of people without space limitations, not knowing each other might limit their interaction. In addition, teachers stated that rapport between group members, the motivations and experiences of members as significant elements influencing interaction. Similarly, the related research highlighted the role of social messages in sustaining interaction (De Noyelles, Zydney, & Chen, 2014; Hara et al., 2000; Rourke et al., 2001). Hence, in order to eliminate the novelty effect on the interaction within the online CoP, some activities can be designed to familiarize the participation in an online CoP and the members. Although in this study there were orientation activities, the scope of the activities can be expanded by adding activities aiming to train them about how to construct knowledge collaboratively in online discussions (Tan, Chai, & Hong, 2008, Lucas et al., 2014), setting norms and expectations for creating a safe environment to involve in honest and reflective conversations (Boada, 2022; Smith & Sivo, 2012), and allocating more time for participants to get to know each other so that they can build rapport and share social messages with each other. Moreover, participants can be scaffolded within discussion activities (Wallen & Tormey, 2019) regarding the positive effect of moderators' support on participants' responsiveness (Mompoint et al., 2022). Even though teachers in this study mentioned the support from the moderator as discussed in the part of performing the roles, the leader role within the assigned role can also guide the discussion activities and increase interaction quality and quantity.

Another aspect highlighted in the interviews affecting interaction between teachers is *communication*. Communicating through online asynchronous discussions was regarded as difficult by teachers. Most of them suggested routine online meetings for easing communication and increasing the quality of interaction. The synchronous meetings were considered as more beneficial to negotiate meaning and co-construct lesson plans. This was supported by another research indicating that participants tended to reach more agreements during negotiation and applied the newly constructed knowledge more frequently in audio/video-based online discussions (Guo, Shea, & Chen, 2022). Although audio/video-based online discussions allowed asynchronous interactions, seeing or hearing the other person contributed to negotiation and application of the newly constructed knowledge. On the other hand, same research revealed that text-based online discussions involved learners in knowledge construction more frequently (Guo, Shea, & Chen, 2022). Similarly, video-enhanced asynchronous discussions were also suggested to provide the feeling of connection with others and to improve a community of inquiry (Clark, Strudler, & Groove, 2015). In this study, the discussions within their synchronous meetings for designing lesson plans were not recorded. Future studies may also involve different forms of asynchronous communication along with synchronous communication. The recording of these activities may also provide information about which communication ways help to increase interaction, in turn knowledge construction within the online CoP.

The other aspect influencing interaction between teachers was stated as *ICT related issues*. Several teachers suggested to use a mobile platform to reach the online CoP frequently and stated the need for notifications throughout the discussions. This is in line with the literature highlighting that within online communities of practice, members might feel distant and forget even the existence of the community (Wenger, White, & Smith, 2009). Hence, mobile accessibility can be considered for the interaction between teachers. The literature related to online professional development also suggested mobile technologies for transforming teachers' practices by providing practical strategies and ideas to enrich instruction (Dean, Zanko, & Turbill, 2015). Hence, the notifications and easy access to the discussion platform via mobile phones might increase interaction. A study also suggested the use of WhatsApp regarding its capacity for instant feedback and added that it could enable social interactions (Chan, 2015). In addition, another study which used WhatsApp community of practices in the context of mathematics teachers indicated that teachers interacted on a daily basis (Mailizat, Johar, Sadli, & Zubaidah, 2022). Furthermore, Boada's study (2022) suggested that the online platforms and tools should be selected carefully to support interaction between teachers.

The functioning of roles

As stated in the previous sections, there were three roles, starter/leader, reporter, and timer, that teachers take to maintain the online CoP while working in small groups collaboratively. The findings related to functioning of roles revealed opinions of teachers about the distribution of the roles, performing the roles, roles to maintain online CoP, extra time for the roles, orientation, and switching roles through activities.

Regarding *the distribution of the roles*, teachers shared that it was democratic, fair and voluntary basis. However, some of the teachers were hesitated to take roles because of having no or little experience in teaching in the school of this organization, the novelty of online CoP and the instability because of the pandemic. Some others also highlighted the disparity between the number of group members and the number of roles as a factor influencing to take roles. Accordingly, teachers wanted to take the responsibility of a participant only. Although some contextual factors like the pandemic cannot be controlled, the hesitations because of the novelty might be solved by planning an orientation for the roles.

The interviews also indicated the need for *orientation of the roles*. Although the descriptions of the roles were shared at the beginning of the implementation of the online CoP, it may be considered to give more details about the responsibilities of the roles. As well as the lack of volunteering to take roles, it affected *performing the roles*. Despite the fact that the participants were informed about the rule that they can switch the roles whenever they needed, the roles were maintained with the first assigned members throughout the online CoP. This influenced the members who took the roles negatively considering *the extra time* they need to allocate for performing the roles. Teachers highlighted the deficiencies in performing the assigned roles by associating it with the workload of teachers and instability because of the pandemic. Since it is known that having a participant leader in the online group is critical for maintaining discussions (Lin et al., 2016), the low performance of the leader role might have a negative effect on interaction and knowledge construction. Several studies emphasized the effect of scaffolding within discussion activities to increase interaction and co-construct knowledge (Wallen & Tormey, 2019; Mompoint et al., 2022). Even though teachers in this study mentioned the support from the moderator, the leader role within the assigned roles is also valuable in guiding the discussion activities and increasing interaction quality and quantity. Similarly, the low performance of timekeeper and reporter roles may also affect the pace of discussion and interaction. Regarding the workload of teachers and the limited time for participation, *switching roles through activities* might be highlighted to address the challenge of performing the roles effectively. In each activity, the ones that will be responsible for these roles can be chosen at the beginning as it was suggested by teachers.

While performing *the roles to maintain the online CoP*, teachers encountered some challenges. While all the roles were affected by the changing deadlines since it became more difficult to follow others' activities, timekeeper roles were also hesitated to remind and encourage others to involve in online discussions. The workload of teachers affected teachers' participation negatively, and in turn, these roles were struggled to maintain their responsibilities. As it was discussed, planning time for professional development activities in teachers' working hours might be a solution to focus on their participation and their roles. It can also prevent continuously changing deadlines for the activities and timekeeper role can effectively do their task based on the plan.

The interviews also indicated that most of the participants considered the selected roles were enough to maintain the online CoP. To share the workload, assigning the roles to two members was suggested. For the new roles that can help, one of the teachers offered a role that is responsible for organizing the implementation times across schools. Since the emergency remote period affected teachers' practices, they were at different places at the curriculum. So, completing the implementations of the lesson plans delayed. In turn, the schedule of the activities was influenced. Even a similar online CoP was conducted during face-to-face learning continues, organizing the implementations might be required since the participants attend from different schools. Another teacher suggested to involve a role model who planned and implemented lesson plans with cognitive tools earlier. Having an experienced teacher who designed and implemented constructivist learning environments might contribute both to maintain the activities and knowledge construction within the discussions.

Suggestions related to online CoP

Teachers also shared some suggestions to maintain the online CoP effectively. Accordingly, while one of them propounded *collaborating with an academician* can be beneficial for their professional development, other one offered planning *peer observations* to see other groups' examples implementations. Collaborating with an expert within an online CoP can be explained with the involvement of different experience levels as stated by Wenger (2000). While an academician in the related field can provide expert-level contributions to knowledge construction, novices can negotiate their understanding with the expert. Moreover, the experts also construct knowledge through these interactions. In line with the literature, this kind of learning communities can construct knowledge resources for the community over time (Lave & Wenger, 1991; Wenger, 2000). Peer observations can also enrich teachers' understanding of how cognitive tools were integrated. It may contribute the discussion after the implementation of the lesson plans. Both self-evaluation and observer's evaluation can provide feedback to revise the lesson plans and identify what can be considered for future implementations. These two suggestions can be associated with the findings of a recent study suggesting that leader, expert, and peer support is needed to motivate teachers to integrate technology in student-centered ways (Chiu, 2022).

Although school leader support is not mentioned directly, the last suggestion can be related with the leader support by encouraging the planning and implementation of constructivist learning environments. In this regard, one of the teachers suggested *adding some time between the design of the lesson plans and the implementation*. Accordingly, teachers could allocate more time to work on the design of the lesson plans. After the planning is completed, teachers should have time to plan the implementation. As it was discussed previously, integrating cognitive tools into the yearly plans can be a solution. Since teachers work on the design of the lesson plans and planning of the implementation before the academic year begins, the implementation including readiness activities might be maintained smoothly within the academic year. The school support in these processes affects the technology integration processes as discussed by several studies (Chiu, 2017; Serriawati & Azwar, 2020).

Gains from Online CoP

The online CoP in this study aimed to support teachers in integrating cognitive tools into mathematics classes by providing an environment in which they collaborated with their colleagues, critically examined, developed, mastered and reflected on new approaches as suggested by Corcoran for continuous development (1995). The findings of the study revealed that as it was aimed, teachers gained knowledge, experienced constructivist learning environments, collaborated with each other while learning how to integrate cognitive tools and shared their experiences with each other. Within a community, they were mutually engaged through sharing experiences (mutual engagement), were committed to a common goal, which is integrating cognitive tools, through collective negotiation (joint enterprise), and produced and adapted knowledge through sharing their ideas, practices, and experiences (shared repertoire) as it was stated as the principles of an effective CoP (Wenger, 1998).

Teachers gained knowledge about what constructivist learning environments mean through watching a video about theoretical framework and examining sample lesson plans integrating cognitive tools. They also gained knowledge about the cognitive tool, Scratch, through a webinar explaining the basics before examining its role in sample lesson plans. In order to experience the cognitive tool, they also involved in some practice activities with Scratch. Moreover, designing the lesson plans integrating cognitive tools and implementing them in their classrooms allowed them to gain experience. These activities allowed them how to align technology with specific mathematics learning objectives as suggested by another study **(**McCulloch, Hollebrands, Lee, Harrison & Mutlu, 2018).

Throughout the activities, teachers shared their ideas and experiences and collaborated. While examining the lesson plans, the discussions helped them share and compare their perspectives and discovered areas of disagreement as it was seen in the analysis of discussion recordings. The interviews corroborated that they were involved in negotiation of meaning and co-construction of knowledge in their design processes. Accordingly, collaborating with both mathematics teachers and ICT teachers eased their designing a lesson plan with a new approach and enriched their perspectives of teaching. Based on the analysis lesson plans, it can be said that teachers applied Jonassen' Constructivist Learning Environment Model in their lesson plans. Hence, the lesson plans can be considered as products of their learning and they were aligned with the expectations of the professional development program.

In line with the literature, teachers discussed their implementations in the classroom related to a new approach and decided to use it in their classrooms (Chen et al, 2009; Kent, Laslo & Rafaeli, 2016). As it was discussed in integration of cognitive tools, teachers stated their willingness to give place constructivist learning environments in their practices after participating in the online CoP. Guskey (2002) also noted that teachers motivated to change their practices by observing positive alterations in students' outcomes. As discussed in previous sections, they witnessed the effect of constructivist learning environments in students' learning. Moreover, examining the other groups' lesson plans and sharing the experiences of their implementations created a shared repertoire for their future studies and they also highlighted their desire to implement other lesson plans produced within the community. Considering the findings of multiple studies highlighting that mathematics teachers had difficulties in how and when to integrate technologies relating with different mathematical concepts (Niess, 2011; Agyei & Voogt, 2016), the sharing of lesson plans across small groups might provide them a support mechanism for integrating technology as cognitive tools. As another study highlighted that effective in-service teacher professional development programs related to technology integration into mathematics classes should be based on practices, interaction, providing experience about technological tools, and providing sample materials (Birgin et al., 2020), this online CoP can be considered as an effective way for teacher professional development about technology integration regarding its gains including knowledge, experience, collaboration and sharing.

Change in Opinions related to Technology Integration

For teachers' technology integration practices, their opinions related to technology integration can be considered critical. The findings of this study revealed that participating in the online CoP influenced their opinions about technology integration. Teachers stated that they learned *a new approach*, which is constructivist learning environments and *new tools* to use as cognitive tools in mathematics classes. As it was discussed in the initial interviews, teachers did not have any prior knowledge about cognitive tools. After the participation, they realized the difference in their teacher-centered approach in their practices and learner-centered approach in integrating cognitive tools. They discovered that student-centered learning environment incorporating ICT changes the traditional passive recipient-role of students to active players of their own learning (Xavier et al., 2018). Regarding the need in the professional development programs about integrating technology in a learner-centered way in Turkey (Gök & Yıldırım, 2015; Göktaş, Gedik, & Baydaş, 2013), it can be deduced that the online CoPs might create a chance to gain teachers the required knowledge and skills for integrating technology as cognitive tools. Moreover, incorporating different technologies such as Excel and Scratch as cognitive tools gained teachers a wider perspective for technology integration. With different tools, they experienced converting a computer-based tool into a cognitive tool by answering the need of in-service teacher training in this issue (Akyol & Sendurur, 2019).

Many studies emphasized that teachers' attitudes towards technology integration is critical for their technology integration practices (Çakıroğlu, 2015; Pamuk et al., 2013; Şahin et al., 2013). Before the participation in the online CoP, there were some teachers who stated their negative opinions related to technology integration. These were related to the incompatibility of mathematics instruction with technology integration, the inducement of technology to easy results, and lack of student awareness in using technology for learning. Comparing their opinions after the implementation of the online CoP, teachers stated that their perspective had changed by learning constructivist learning environments. One of them shared her discovery of the difference of the integration of technology in a learner-centered way. Another one highlighted the role of participating in this program as gaining confidence in designing and implementing similar lesson plans. Considering the perceived competence in technology integration as a significant factor in technology integration (Aslan & Zhu, 2018; Backfisch et al., 2021), this opinion change may affect technology integration practices positively. Regarding these changes in their opinions, as it was discussed in the initial interviews, modeling how to integrate technology within an online CoP might lead to change their negative opinions, broaden their perspective, and foster a culture supporting technology integration (Ertmer, 1999, 2005; Glazer, Hannafin & Song, 2005; Vanatta & Fordham, 2004). Moreover, teachers' learning of constructivist learning environments by experiencing through their subject courses may have been effective in changing their beliefs as discussed by a prior study (Aslan & Zhu, 2018).

As it was discussed in the initial interviews, the emergency remote learning period, teachers experienced technology integration in their classes more than they used to do. It also led them to *question the role of integrating technology* by considering the ways of technology integration to support students' learning. After the participation in this online CoP, this new approach guided them to consider technology integration with both teacher-centered and learner-centered ways to support students' learning. Experiencing learning with technology approach highlighted the role of cognitive tools in students' understanding of mathematical concepts, the relationship of mathematics and real life, and active involvement of students in their learning process. These positive student outcomes may have led to increase utility-value levels. In turn, higher utility-value levels might contribute to teachers' technology integration practices in future (Backfisch et al., 2020; Scherer et al, 2015; Wozney et al., 2006). Learning with technology approach reinforced learner-centered mathematics classes. The perspective that associates the purpose of technology integration majorly with students' attention and motivation was changed and teachers discovered its effect on students' learning as it was discussed previously in this chapter.

Applying the principles of constructivist learning environments also motivated them to consider technology integration with a thorough *lesson planning*. The detailed planning allowed them to implement technology integration as cognitive tools easily. This finding is also in line with teachers' suggestions of integrating cognitive tools into the yearly plan, determining appropriate cognitive tools, and planning with ICT teachers for the integration of cognitive tools. All these suggestions supported the need of detailed consideration of constructivist learning environments. Moreover, prior research noted that focusing on learning goals while deciding to use a technology (Ermeling, Heibert, & Gallimore, 2015) and planning a lesson plan including real-world problems requires more time for teachers (Cheng & Toh, 2015).

With the help of the online CoP, teachers stated that they realized the need to improve themselves in technology integration by supporting the findings of prior studies indicating mathematics teachers' lack of knowledge and skills in technology integration (Erbaş, Çakıroğlu, Aydın, & Beşer, 2006; Çakıroğlu, Güven, & Akkan, 2008; Bozkurt, Bindak & Demir, 2010; Kaleli Yılmaz, 2015; Birgin, Uzun & Mazman-Akar, 2020). Although some of them perceived themselves competent before the participation, their opinions changed about their *perceived level of technology integration*. On the other hand, some of them realized that technology integration did not require advanced level of use technology as they had considered. Regarding previous studies that underlined the role of self-efficacy in limiting technology integration practices (Hechter &Vermette, 2013, Hew & Brush, 2007;

Inan & Lowther, 2010a; Kopcha, 2012), this change in their self-efficacy beliefs can be associated with their *willingness* to integrate technology. They shared that they decided to give more place to technology in their lessons to support students' learning. In addition, they highlighted the necessary *adaptation of teachers* by learning to integrate technology effectively.

Regarding all these changes in teachers' opinions related to technology integration, it can be deduced that involving in an effective professional development program through online CoP may affect teachers' opinions in a positive way, encourage them to integrate technology and alter their existing practices. Similarly, a recent study proposed that teacher professional development programs can promote teachers' performance and persistence of integrating technologies into their practices by focusing on teachers' self-efficacy and utility-value (Backfisch et al., 2021). Accordingly, self-efficacy of teachers can be improved by providing chances to experience technology integration in their classrooms and utility-value can be enhanced by emphasizing benefits of technology integration (Backfisch et al., 2021). In line with this, the current study allowed teachers to experience how to integrate a cognitive tool in their classes from design process to implementation and to observe the effect of constructivist learning environments on students' learning.

Technology Integration Prior to the Participation in the online CoP

As it was discussed in the initial interviews, teachers shared their technology integration practices prior to the participation in the online CoP. Accordingly, they mainly integrated technology for instructional delivery including videos, visualization, simulations, and drill and practice as well as assessment and motivation. These are in line with the findings of the initial interviews. The common feature of these practices was teacher-centered approach. This traditional approach in technology integration was congruent with the findings of previous studies indicating that teachers preferred to incorporate technology in a teacher-centered way to complement their traditional ways of teaching (Mwalongo 2011; Thorvaldsen, Vavik & Salomon, 2012). Most of them positioned students as consumers with a learning from technology approach by under-utilizing technology integration in mathematics education as noted by other studies (Becker & Ravitz, 2001; Conlon & Simpson, 2003; Cuban, 2001). Although some of them such as student projects created an environment for student products, they were the application of what they had learned. The technology did not take a role of a learning partner as cognitive tools do. This finding also highlighted the role of the online CoP in gaining teachers a new perspective for technology integration as discussed in the changes in teachers' opinions related to technology integration.

Teachers' Opinions related to Teacher Professional Development

The findings of the study indicated that teachers highlighted the role of the professional development about integration of cognitive tools in *enhancing experiential learning*. By contrast with the misleading assumption that when teachers are engaged in training programs, they can easily carry the practices into their classrooms that they have been shown (Datnow, Hubbard, & Mehan, 2002), the online CoP about constructivist learning environments allowed teachers to experience designing a lesson plan collaboratively and implementing it in class as an experiment. After that, teachers shared their observations related to their experiences and discussed the application of the model, the problems, possible solutions and further considerations. Experiencing integration of cognitive tools was also underlined by teachers as it was discussed in the gains from the online CoP. Similarly, the experiential learning model focuses on learning through concrete experiencing, reflecting critically, abstract conceptualizing and actively experimenting (Kolb, 2015). In this program, it can be concluded that teachers were involved in experiential learning and experiencing a new approach in technology integration helped their learning process. The significance of professional development programs providing experiential learning opportunities was also corroborated with a recent study with English foreign language teachers in Turkey which allowed teachers to experience new practices related to technology integration in collaboration with their colleagues and co-reflected on student outcomes based on the implementations (Songül, 2019). Hence, as teachers noted in this study, the teacher professional development programs can be designed allowing teachers to involve in experiential learning while learning new approaches in technology integration.

They compared the experience of participating in this program with their *prior teacher professional development experiences*. In line with the literature, teachers were mostly involved in traditional professional development programs (Lieberman & Mace, 2008; Ozoglu, 2010). Although one of the teachers highlighted that a conference requiring them producing and implementing a lesson plan with a constructivist approach, and interacting and collaborating with other teachers based on the product as suggested by many studies (Desimone, Porter, Garet, Yoon &Birman, 2002; Guskey, 2003; Guskey & Yoon, 2009; Ingvarson, Meiers, Beavis, 2005; Lee, 2005), the theoretical framework that was accepted as a basis and the sample lesson plans showing how it was applied in classrooms were considered as missing. In this regard, teachers emphasized the significance of *the sequence of activities* in their learning process within the scope of this professional development program. So, helping teachers understand the theory behind the lesson plans and provide sample lessons to examine how it was applied can be considered crucial elements before they experience the design and implementation processes.

Although it was considered that it had a *long duration*, which was related to the pandemic, the flexibility provided during the online CoP allowed them to follow the steps during such an extraordinary situation. As it was discussed in previous sections, teachers stated their workload, lack of time during working hours, and the instability of emergency remote learning process as challenges for participating in the online CoP. Hence, considering their current circumstances and adjusting the schedule of the program and providing *flexibility* might affect their participation positively. On the other hand, the long duration of the program can also be evaluated as a positive factor regarding the findings of the studies revealing that professional development courses are too short to lead teachers to make significant and lasting changes in their practices (Amanatidis 2014).

Regarding all the findings related to the opinions of teachers after the implementation of online CoP and the related literature, it can be noted that the online CoP allowed teachers to gain knowledge about technology integration as cognitive tools, experience it through designing and implementing, collaborate throughout the learning process, and share their ideas with colleagues as it was intended. Teachers observed the effect of constructivist learning environments on students' learning process, which changed their opinions positively about technology integration. They defined what is required for integration of cognitive tools including their planning of lesson plans, their roles within CLEs, readiness of students, teachers' competencies and organizational and contextual factors. Combining all these results, it can be concluded that the online CoPs can be considered as continuous and collaborative learning environments for teachers. By providing the necessary time within working hours for their participation and training teachers about how to construct knowledge collaboratively within online discussions might contribute to the impact of online CoPs. Moreover, ensuring collaborative and experiential learning environments for in-service teachers about technology integration practices might contribute to the policies aiming to integrate technology as a learning partner.

5.2 Conclusion

Combining the needs of positioning technology as a tool in students' learning with a constructivist perspective and providing effective professional development programs for ICT integration for teachers, this study intended to find out the impact of the online CoP for professional development related to integration of technology as cognitive tools in mathematics teaching. For teachers' meaningful integration of cognitive tools, the online CoP in this study included various activities in which teachers participated to learn how to integrate cognitive tools in mathematics teaching. These professional development activities were designed regarding practice, interaction, experience about tools, and sample lesson plans to be an effective in-service teacher training about technology integration through online CoP.

The impact of a professional development intervention in educational settings is suggested to examine through five levels; reactions, learning, organizational support and change, use of new knowledge and skills and students' learning outcomes by Guskey (2000). This qualitative study examined the impact of the program by analyzing teachers' opinions before and after the participation in the online CoP, teachers' discussion messages throughout the activities, and lesson plans that teachers designed. Although the impact of the online CoP was not observed within a long time period, the findings can be associated with these levels.

Regarding reaction level, teachers stated that the participation in the online CoP provided them an environment in which they can gain knowledge about the integration of cognitive tools, share their opinions, collaborate and experience the design and implementations of the lesson plans including cognitive tools. The experience of participating in an online CoP about integrating technology as cognitive tools was considered as satisfactory in terms of these gains from the online CoP. Within the online CoP, teachers were provided opportunities to learn, grow, and change their teaching practices in collaboration with their colleagues by working on their subject areas.

Moreover, considering the experience of participating in such an online CoP, teachers shared the factors influencing their participation, interaction between them, and the functioning of roles as well as their suggestions to maintain an online CoP for teacher professional development related to constructivist learning environments. Accordingly, it can be concluded that while teachers were satisfied with the teacher professional development program through online CoP which provided them an experiential learning environment which includes step-by-step activities in a long term by providing flexibility, the experience of online CoP can be improved by considering the factors influencing participation of teachers, interaction between teachers, the functioning of roles and the suggestions of teachers to maintain online CoP.

According to the findings, while teachers were satisfied with active participation in the professional development program, the workload, changes in their motivation, instability because of pandemic and lack of time during working hours hindered their participation. Interaction within online discussions were also affected by these factors and the novelty of participating in online discussion environments with the new colleagues. Asynchronous communication and ICT related issues also had an effect on interaction. To maintain an effective online CoP, teachers were highlighted the functioning of roles. Based on the findings, regarding extra time required for the roles, the group members can switch the roles within activities. Moreover, time within working hours can help teachers perform their roles effectively as well as participate actively in discussions. In order to make sure that they can understand the scope of the roles within activities to volunteer and perform better, orientation activities can be planned.

The second level, which is learning, is observed through the examination of the lesson plans as the products of their participation in online CoP. Based on the analysis of designed lesson plans, it can be said that teachers reflected the indicators of constructivist learning environments. Hence, it can be concluded that they could have applied what they learnt throughout the program and realized the areas to be improved and the required considerations for further implementations through their discussions. Moreover, the knowledge construction levels throughout the activities revealed teachers' learning. The related findings point out that teachers' online discussion messages mainly contained the first phase, sharing and comparing information, and the second phase, discovering and exploring dissonance or inconsistency. This finding can be associated with the novelty of participating in online CoP, the novelty of participants, the nature of the discussion activities, and the lack of scaffolding by means of assigned roles within the small groups. Regarding the nature of synchronous meetings in which small groups worked on the design of lesson plans, it can be suggested to examine both asynchronous and synchronous online discussion activities which might give a full picture of knowledge construction processes. In addition, the interviews conducted at the end of the online CoP indicated teachers' opinions about their own learning. They highlighted that their perspective related to technology integration was expanded with the effect of the program. The findings revealed that teachers learned a new approach and new tools, questioned the role of technology integration, recognized their perceived level of technology integration, the role of lesson planning in technology integration practices, stated their willingness to integrate technology, and realized the need for teachers' adaptation. These gains from the online CoP corroborated that participating in an online CoP for technology integration as cognitive tools helped teachers learn how to convert a computer-based tool into a cognitive tool by answering the need of in-service teacher training programs in technology integration.

The third level is organizational support and change. Although this impact of the professional development program cannot be evaluated at the end of the program within the scope of this study, the interviews indicated that what is needed for the integration of cognitive tools in terms organizational support and change to integrate constructivist learning environments in classrooms. Based on the experience of designing and implementing lesson plans within the online CoP, teachers identified that they needed to allocate more time for implementations, which is also related with the integration of constructive learning environments' plannings to the yearly-plan and organization's encouragement and flexibility to plan such interdisciplinary studies by providing necessary support. This support at school level can include allocating time for professional development activities and collaborative work of mathematics and ICT teachers and encouraging learning with technology approach instead of associating success only with the results of the national exams. Furthermore, from a wider perspective, redesigning curriculum and changing the perspective towards national exams can be regarded as enablers for adoption of constructivist learning environments.

The fourth level is use of new knowledge and skills. Similarly, this level cannot be evaluated unless enough time is given for teachers to integrate cognitive tools in their practices. However, the findings of this study revealed teachers' willingness to implement learning-with technology approach. They stated they would like to benefit from the lesson plans designed by their peers in other groups. This shared repertoire provided them to experience constructivist learning environments with different examples. Moreover, they can benefit from other lesson plans for their plannings which contributed to the required persistence for authentic and meaningful technology integration. In time, they can adapt and design new lesson plans including variety of cognitive tools. Then further research can reveal how they use their new knowledge and skills in designing and implementing constructivist learning environments.

The final level students' learning outcomes. Although students' learning outcomes were not assessed by teachers in the long run, teachers stated their opinions about the effect of constructivist learning environments on students' learning based on their implementations. Accordingly, they observed learner attention and motivation, constructionism, understanding, active participation, integration of mathematics and daily life, integration of mathematics and technology, collaboration, developing thinking skills, easing task, and autonomous learners in the implementations of the lesson plans. These positive opinions related to the effect of technology integration as cognitive tools motivated teachers to involve cognitive tools in their practices. In the long run, the impact of this program on student outcomes can be observed as teachers integrate cognitive tools into their practices by using their knowledge and skills from the online CoP and the required organizational support is provided for their successful integration.

Based on the findings of the current study and the related literature, it can be said that this study contributed to research by providing teachers' experiences and challenges in the design and implementation process of constructivist learning environments. Moreover, in line with the aim of gaining students technological competence (MoNE, 2018), this teacher professional development program helped teachers learn how to integrate technology as a learning partner in their practices and observe the impact of using cognitive tools on students' understanding of mathematics which is critical regarding the need for enhancing students' learning. Furthermore, the online CoP allowed teachers to involve in a professional development program in which they can collaborate with other teachers without location and time limitations, benefit from others' experiences, co-construct knowledge together, and support each other while experiencing a new approach. In the light of the findings of the study and the design of the implemented teacher professional development program, the design guidelines for an online CoP that enhances teachers' integration of cognitive tools were compiled in Figure 12.

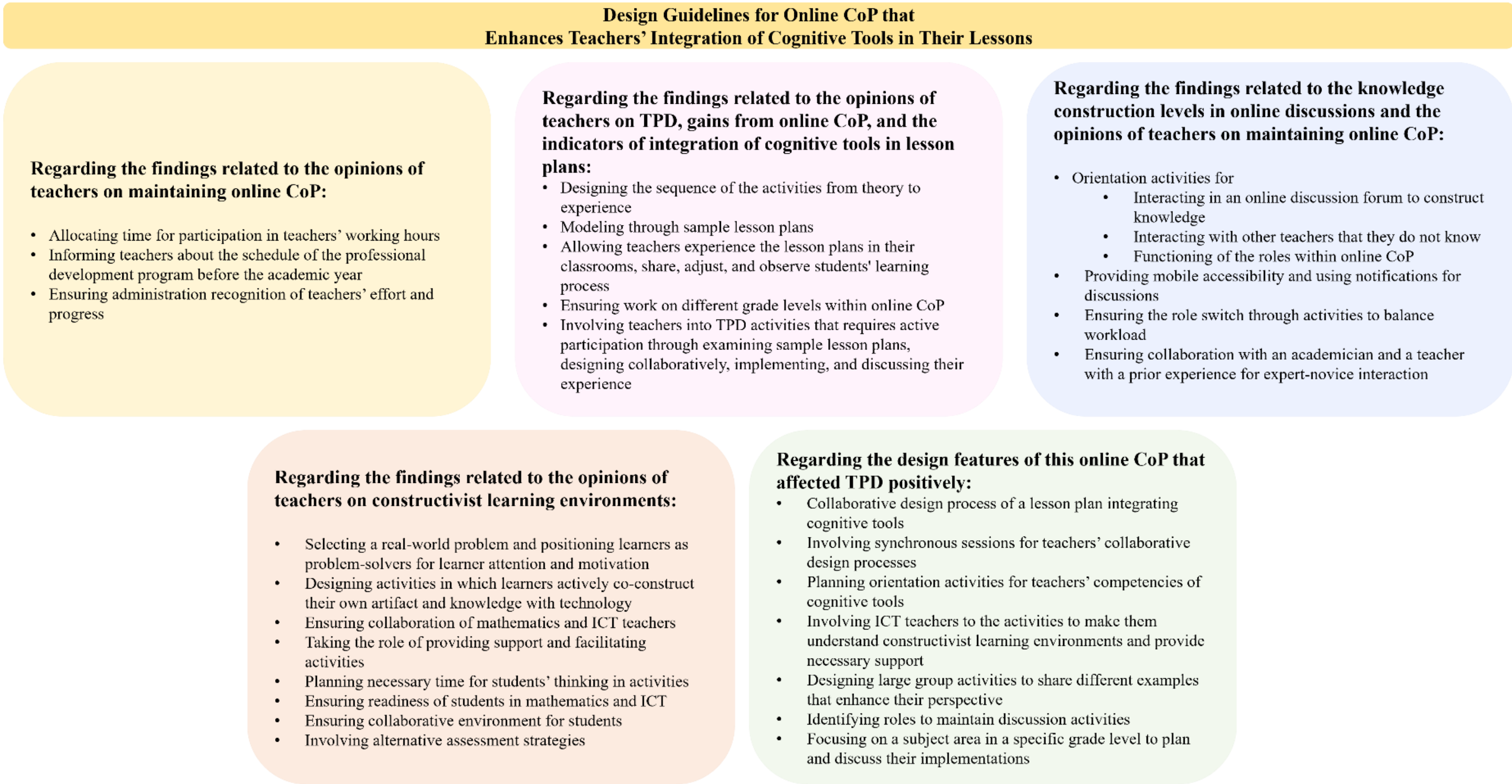


Figure 12 Design guidelines for online CoP that enhances teachers' integration of cognitive tools in their lessons

5.3 Implications of the Study for Practice

Although the findings of this study do not provide generalizations beyond its context, there were some recommendations for professional development programs and designing and implementing lesson plans integrating cognitive tools for similar contexts. Considering its possible contributions for future practices, the suggestions were compiled and presented in this part of the report based on the findings of this study.

Suggestions for designing teacher professional development programs:

- Allocating time for professional development activities in teachers' working hours might be considered as a critical element for their participation, the quality of interaction between teachers, and in turn, the impact of the professional development programs.
- Along with the dedicated time for professional development, teachers might be informed about the schedule of the program. The readiness activities and implementations might be integrated to their yearly plan so that the curriculum pressure is decreased while they are experiencing a new method in their practices.
- Considering the fact that participating in an online CoP requires learners to interact in an online discussion environment and construct knowledge collaboratively, the teacher professional development programs might include orientation activities aiming to address the novelty of both interacting in an online discussion forum and interacting with other teachers that they do not know. To support teachers' knowledge construction throughout the activities, the sample discussion sections can be shared, and phrases or incomplete sentences can be provided to help them construct knowledge through elaboration, comparison, negotiation, synthesis, or asking. In order to improve interaction, synchronous warm-

up sessions might be planned at the beginning. Hence, this might help them develop group dynamics by getting know each other.

- While maintaining an online CoP, role assignment might be done considering the equal workload distribution. Switching roles through activities might ensure each member's taking responsibility of one of the roles within the activities. At the beginning of the online CoP, the roles can be assigned for each activity. Throughout the process, based on the needs, teachers can define new roles and assign them or share the responsibility of one role with another member. These can be defined as norms of the community. Moreover, in order to indicate the scope of the roles and their duties, the orientation activities might also include how the roles function within the online CoP.

- Providing mobile accessibility and using notifications for discussions might be considered for increasing interaction between teachers within online CoPs.

- During the online CoP, informing the administration about the progress and teachers' efforts might help teachers to be recognized by their administration and stay motivated to participate.

- The sequence of the activities within the online CoP might be regarded. The activities might allow participants to gain knowledge about integrating cognitive tools, examine sample lesson plans, and experience the design and implementation process.

- Modeling how to apply constructivist learning environments with sample lesson plans might lead to broaden their perspectives integrating technology regarding learner-centered approaches and associate technology integration with their subject areas. Moreover, it might also influence opinions related to technology integration.

- Experiencing the lesson plans they produced in their own contexts might provide them confidence in integrating cognitive tools, help them identify the necessary adjustments, and share their experience with other teachers in their department to integrate cognitive tools in the yearly plans. Moreover, their observations related to student outcomes might affect their willingness to apply constructivist learning environments.

- Activities involving teachers' collaboration with mathematics teachers and ICT teachers might be included in the design process of the lesson plans integrating cognitive tools. It might provide the necessary peer support while trying a new approach as well as improving creativity. In addition, teachers' ICT competencies related to the use of cognitive tools might require support from ICT teachers.

- Collaborating an academician who had expertise in integrating cognitive tools and a teacher with a prior experience in constructivist learning environments might be considered for creating chances for expert-novice interaction for knowledge construction.

- Future online CoPs aiming to improve teachers' integrating cognitive tools skills might focus on different grade levels in each small group that allows teachers design different lesson plans throughout middle school and high school. It might create a continuum in learning with technology. Moreover, working on different cognitive tools within small groups may provide a wider perspective for integrating technology as cognitive tools through sharing across small groups.

- Regarding the findings indicating that teachers applied Designing CLE Model in the lesson plans as a result of their participation and observed its effect on students' learning processes, involving teachers into activities that requires active participation through examining sample lesson plans, designing lesson plans collaboratively, implementing, and discussing their experience can be considered for designing teacher professional development activities through online CoP.

Suggestions for designing and implementing lesson plans integrating cognitive tools

- Selecting an engaging, appealing, and authentic problem at the center of the lesson plans can be considered as an essential element for students' motivation. It may also help learners to relate technology, mathematics, and real-life problems. It might position learners as problem solvers in a real-life problem situation, which may motivate learners to deal with the challenges to solve the problem.

- Designing activities in which learners co-construct their own artifact and knowledge with the help of the cognitive tools can make learners actively participate in lessons. This involvement might also contribute their understanding of the topic and developing thinking skills throughout the activities.

- Regarding that dealing with ill-structured problems within a constructivist learning environments can be a new approach for students, providing support might be considered by teachers through modeling, coaching, and scaffolding. Giving students more chances for approaching learning mindfully and regulating their own learning process might develop these skills and, in turn, the classroom management might become easier in time.

- In order to provide learners necessary time for thinking, manipulating, observing, discussing, and deciding for problem-solving, duration of lessons might be increased for constructivist learning environments. Blocks of lessons might create more chance for collaborative working.

- Before the implementation of constructivist learning environments, students' ICT readiness and mathematics readiness might be considered. Their prior knowledge might be checked, and necessary activities might be planned in order to help them learn with technology by using their prior knowledge and skills. Moreover, students may have negative attitudes towards ICT and mathematics. Before the implementation, their attitudes or bias might be regarded to plan support mechanisms. Grouping students with their peers that may help them progress in problem-solving and learning with technology might provide them support they need.

- The learning environment can be designed in a way that students can collaborate, discuss, and build an artefact with the help of cognitive tools. Working in an ICT lab might provide the necessary collaboration environment while learning with technology and ensure the required support from their peers and teachers.

- As the lesson plans integrating cognitive tools are integrated into the yearly plan, alternative assessment strategies might be involved in the overall assessment. Students' knowledge construction, self-regulation, collaboration, and critical, creative, and complex thinking skills in activities and products can be assessed.

5.4 Recommendations for the Further Research

- The implementations of the lesson plans in this study were conducted during the pandemic. There were differences in different cities about the emergency remote learning. While most of them implemented in a remote environment, some of them had chances to implement the lesson plans in lab settings at schools. The future studies might consider conducting the professional development program through an online CoP while the school system functions in face-to-face learning environments.

- In order to observe knowledge construction levels through all activities, synchronous sessions for the design of lesson plans might be recorded and analyzed in a similar way.

- The novelty of participating in an online CoP for professional development in study may have limited teachers' knowledge construction in online discussions. Further research can focus on developing knowledge construction skills in online discussion environments and search for its effect on the knowledge construction levels within the online CoP.

- The current study was conducted with the participants from different private schools of an organization in Turkey. These findings can be compared with a future study with participants from public schools.

- The effect of the constructivist learning environments on students' learning can be investigated by experimental studies to indicate whether or not there is a significant effect. Moreover, the students' opinions related to integrating cognitive tools can be gathered. The results might also contribute teachers' future decisions to integrate cognitive tools and adjust the lesson plans.

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APPENDICES

A. Approval of Human Subjects Ethics Committee at METU

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

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12 Aralık 2019

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof.Dr. Zahide YILDIRIM

Danışmanlığını yaptığınız **Dicle ÇOLPAN'ın "Matematik Öğretiminde Teknolojinin Bilişsel Araç Olarak Kullanılması Konusunda Öğretmen Mesleki Gelişimini Hedefleyen Bir Çevrimiçi Uygulama Topluluğu: Örnek Olay İncelemesi"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **476 ODTU 2019** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız

Doç.Dr. Mine MISIRLISOY
Başkan

Prof. Dr. Tolga CAN
Üye

Doç.Dr. Pınar KAYGAN
Üye

Dr. Öğr. Üyesi Ali Emre TURGUT
Üye

Dr. Öğr. Üyesi Şerife SEVİNÇ
Üye

Dr. Öğr. Üyesi Müge GÜNDÜZ
Üye

Dr. Öğr. Üyesi Süreyya Özcan KABASAKAL
Üye

B. Informed Consent Form

Bu çalışma, Orta Doğu Teknik Üniversitesi Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü'nde doktora öğrenimine devam etmekte olan Dicle Çolpan tarafından Prof. Dr. Zahide Yıldırım danışmanlığında gerçekleşmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın Amacı Nedir?

Araştırmanın amacı, ilköğretim matematik öğretmenlerinin çevrimiçi uygulama topluluğu aracılığıyla bilgi ve iletişim teknolojilerini derslerinde bilişsel araç olarak kullanmalarına yönelik mesleki gelişim programının etkisini incelemektir.

Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?

Araştırmaya katılmayı kabul ederseniz, sizden beklenen, araştırmacı tarafından tasarlanan çevrimiçi eğitim programında, webinarlara katılmak, tartışmalara katılmak ve iş birliği içinde teknolojinin bilişsel araç olarak derste kullanılacağı bir ders planı hazırlamak ve dersinizde uygulamaktır. Eğitim sonrasında ise sizden beklenen teknolojinin bilişsel araç olarak kullanılmasına ve ilgili eğitim sürecine ait düşüncelerinizi öğrenmek için araştırmacıyla yapılacak olan görüşmelere katılmaktır.

Sizden Topladığımız Bilgileri Nasıl Kullanacağız?

Araştırmaya katılımınız tamamen gönüllülük temelinde olmalıdır. Çevrimiçi ortamda ve görüşmede sizden kimlik veya kurum belirleyici hiçbir bilgi istenmemektedir. Cevaplarınız tamamıyla gizli tutulacak, sadece araştırmacılar tarafından değerlendirilecektir. Katılımcılardan elde edilecek bilgiler toplu halde değerlendirilecek ve bilimsel yayınlarda kullanılacaktır. Sağladığınız veriler gönüllü katılım formlarında toplanan kimlik bilgileri ile eşleştirilmeyecektir.

Katılımınızla İlgili Bilmeniz Gereken Diğer Konular Nelerdir?

Çevrimiçi ortamda ve görüşmede genel olarak kişisel rahatsızlık verecek sorular bulunmamaktadır. Ancak, katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz çalışmayı yarıda bırakıp bu araştırmadan ayrılabilirsiniz. Böyle bir durumda araştırmacıya, çalışmadan çıkmak istediğinizi söylemek yeterli olacaktır.

Araştırmayla İlgili Daha Fazla Bilgi Almak İçin Ne Yapabilirsiniz?

Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için ODTÜ Bilgisayar ve Öğretim Teknolojileri Eğitimi Bölümü doktora öğrencisi olan Dicle Çolpan (E-posta: dicle.colpan@gmail.com) ile iletişim kurabilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.

(Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

İsim Soyad	**Tarih**	**İmza**
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C. Interview Protocols

Initial Interview Protocol

Tarih:___/___/2021 Saat (Başlangıç/Bitiş): ______/________

Merhaba, adım Dicle Çolpan. Orta Doğu Teknik Üniversitesi Bilgisayar ve Öğretim Teknolojileri Eğitimi Anabilim Dalı'nda doktora öğrencisiyim. Aynı zamanda Türk Eğitim Derneğinde eğitim uzmanıyım.

Bu çalışma, benim doktora tezim kapsamında Prof. Dr. Zahide Yıldırım danışmanlığında gerçekleşmektedir.

Bu çalışma kapsamında, siz de 2020-2021 eğitim öğretim yılında TED Okullarında 6. Sınıf seviyesinde görev alan matematik öğretmeni olarak "Teknolojinin Bilişsel Araç Olarak Kullanılması" adlı çevrimiçi uygulama topluluğuna katılım sağlayacağınızı ilettiniz. Bu görüşmede teknolojinin derslerde kullanılmasına ilişkin düşüncelerinizle ilgili bilgi toplamaya çalışacağım.

Görüşmemize geçmeden önce, görüşmemizin gizli olduğunu ve araştırma raporunda gerçek adınızın yerine takma isimlerin kullanılacağını belirtmek isterim. Bu görüşme kapsamında verdiğiniz bilgiler sizi belli etmeyecek şekilde toplu olarak değerlendirilecek ve bilimsel yayınlarda kullanılacaktır. Sağladığınız veriler "Araştırmaya Gönüllü Katılım Formları"nda toplanan kimlik bilgileri ile eşleştirilmeyecektir.

Görüşmemize başlamadan önce sormak istediğiniz soru ya da belirtmek istediğiniz herhangi bir düşünceniz var mı?

Görüşmelerin kaydedilmesine izin veriyor musunuz? Sesli olarak verdiğiniz bilgiler yazıya geçirilince ilgili doküman size gönderilecektir. O zaman verdiğiniz bilgileri kontrol edip kullanılmasını istemediğiniz bilgileri silebilirsiniz.

Görüşmenin yaklaşık olarak 15-20 dakika süreceğini tahmin ediyorum. İzin verirseniz kaydı başlatıp sorulara geçiyorum.

"Teknolojinin Bilişsel Araç Olarak Derslerde Kullanılması" Konulu Çevrimiçi Mesleki Gelişim Programına Katılmadan Önce:

Bilgi ve İletişim Teknolojilerinin Öğretimde Kullanılması ile İlgili Öğretmenlerin Görüşleri

1- Bilgi ve iletişim teknolojilerini derslerinizde nasıl kullanıyorsunuz? Örnek vererek açıklayabilir misiniz?
    - Ders öncesinde, ders sürecinde, dersten sonra
2- Bilgi ve iletişim teknolojilerini kullandığınız derslerde olumlu gördüğünüz şeyler neler? Neden?

3- Bilgi ve iletişim teknolojilerini kullandığınız derslerde olumsuz gördüğünüz şeyler neler? Neden?
4- Bilgi ve iletişim teknolojilerinin derslerde kullanımı ile ilgili karşılaştığınız zorluklar neler? Açıklayabilir misiniz?
5- Bilgi ve iletişim teknolojilerinin derslerde bilişsel araç olarak kullanılması size ne ifade ediyor? Açıklayabilir misiniz?

Final Interview Protocol

Tarih:___/___/2021 Saat (Başlangıç/Bitiş): ______/________

Merhaba, adım Dicle Çolpan. Orta Doğu Teknik Üniversitesi Bilgisayar ve Öğretim Teknolojileri Eğitimi Anabilim Dalı'nda doktora öğrencisiyim. Aynı zamanda Türk Eğitim Derneğinde eğitim uzmanıyım.

Bu çalışma, benim doktora tezim kapsamında Prof. Dr. Zahide Yıldırım danışmanlığında gerçekleşmektedir.

Bu çalışma kapsamında, siz de 2020-2021 eğitim öğretim yılında TED Okullarında 6. Sınıf seviyesinde görev alan matematik öğretmeni olarak "Teknolojinin Bilişsel Araç Olarak Kullanılması" adlı çevrimiçi uygulama topluluğuna katılım sağladınız. Teknolojinin bilişsel araç olarak kullanımına ilişkin bir video izlediniz, örnek ders planları inceleyerek tartışmalara katıldınız, grup arkadaşlarınızla birlikte yeni ders planları oluşturdunuz ve sınıflarınızda uyguladınız. Uygulama sonrası da tartışmalara katılım sağladınız. Bu görüşmede ise teknolojinin bilişsel araç olarak kullanılmasına ve ilgili eğitim sürecine ait düşüncelerinizle ilgili bilgi toplamaya çalışacağım.

Görüşmemize geçmeden önce, görüşmemizin gizli olduğunu ve araştırma raporunda gerçek adınızın yerine takma isimlerin kullanılacağını belirtmek isterim. Bu görüşme kapsamında verdiğiniz bilgiler sizi belli etmeyecek şekilde toplu olarak değerlendirilecek ve bilimsel yayınlarda kullanılacaktır. Sağladığınız veriler "Araştırmaya Gönüllü Katılım Formları"nda toplanan kimlik bilgileri ile eşleştirilmeyecektir.

Görüşmemize başlamadan önce sormak istediğiniz soru ya da belirtmek istediğiniz herhangi bir düşünceniz var mı?

Görüşmelerin kaydedilmesine izin veriyor musunuz? Sesli olarak verdiğiniz bilgiler yazıya geçirilince ilgili doküman size gönderilecektir. O zaman verdiğiniz bilgileri kontrol edip kullanılmasını istemediğiniz bilgileri silebilirsiniz.

Görüşmenin yaklaşık olarak 40-50 dakika süreceğini tahmin ediyorum. İzin verirseniz kaydı başlatıp sorulara geçiyorum.

Teknolojinin Bilişsel Araç Olarak Derslerde Kullanılması" Konulu Çevrimiçi Mesleki Gelişim Programına Katıldıktan Sonra:

Bilgi ve İletişim Teknolojilerinin Öğretimde Kullanılması ile İlgili Öğretmenlerin Görüşleri

1. Katıldığınız “Teknolojinin Bilişsel Araç Olarak Derslerde Kullanılması” konulu çevrimiçi mesleki gelişim programı, eğitimde teknoloji kullanımı konusunda fikirlerinizi nasıl etkiledi? Teknolojinin eğitimde kullanımı ile ilgili değişen ve değişmeyen fikirleriniz nelerdir?
2. Bu eğitimden sonra, teknolojinin derslerde kullanımı konusunda neler yapmayı planlıyorsunuz?
3. Bu eğitim kapsamındaki deneyimlerinize (ders planı oluşturma ve derslerinizde uygulama) dayanarak, teknolojinin bilişsel araç olarak derslerde kullanılmasının öğretmenler için olumlu ve olumsuz yanları nelerdir?
4. Bu eğitim kapsamındaki deneyimlerinize dayanarak (ders planı oluşturma ve derslerinizde uygulama) dayanarak, teknolojinin bilişsel araç olarak derslerde kullanılmasının öğrenciler için olumlu ve olumsuz yanları nelerdir?

5. Teknolojinin geleneksel bir yaklaşımla derslerde kullanımı ile bilişsel araç olarak derslerde kullanımını kıyaslandığınızda neler söyleyebilirsiniz?

Teknolojinin Bilişsel Araç Olarak Kullanılmasına Yönelik Çevrimiçi Uygulama Topluluğunun Etkisi ile İlgili Öğretmen Görüşleri

6. Bu eğitimden önceki uygulamalarınızda, derslerinizde teknolojinin bilişsel araç olarak kullanımını ne derecede gerçekleştirdiğinizi düşünüyorsunuz? Neden? Örnek verebilir misiniz?
7. Katıldığınız mesleki gelişim etkinliklerinin (Örneğin, webinar, ders planı inceleme, ders planı oluşturma vb.) sizin teknolojinin bilişsel araç olarak kullanılması hakkındaki gelişiminize nasıl bir katkısı oldu?
    - Bundan sonraki derslerinizde, teknolojinin bilişsel araç olarak kullanıldığı ders planları oluştururken nasıl etkileyeceğini düşünüyorsunuz? Neden?
    - Bundan sonraki derslerinizde, teknolojinin bilişsel araç olarak kullanıldığı ders planlarını uygularken nasıl etkileyeceğini düşünüyorsunuz? Neden?

Teknolojinin Bilişsel Araç Olarak Kullanılmasına Yönelik Çevrimiçi Uygulama Topluluğunun Öğretim Tasarımı ile İlgili Öğretmen Görüşleri

8. Katıldığınız çevrimiçi uygulama topluluğunda, bilişsel araçlarla ilgili yapılan webinar, örnek ders planı inceleme ve ders planı oluşturma etkinliklerinizi nasıl etkiledi?
9. İncelediğiniz örnek ders planları, teknolojinin bilişsel araç olarak kullanıldığı ders planı oluşturma etkinliklerinizi nasıl etkiledi?
10. Katıldığınız çevrimiçi uygulama topluluğunda, Scratch ile ilgili yapılan webinar, örnek ders planı inceleme ve ders planı oluşturma etkinliklerinizi nasıl etkiledi?

11. Örnek ders planı incelerken, ders planı oluştururken ve uygulama sonrası paylaşım etkinliğinde, hangi rolde görev aldınız? Ne tür sorumluluklarınız vardı açıklar mısınız?
12. Örnek ders planı incelerken, ders planı oluştururken ve uygulama sonrası paylaşım etkinliğinde, rol dağılımının nasıl olması gerektiğini düşünüyorsunuz?
    - Grubun kendi içinde rolleri belirlemesi ve rol dağılımını yapması hakkında ne düşünüyorsunuz?
    - Örnek ders planı incelerken, ders planı oluştururken ve uygulama sonrası paylaşım etkinliğinde, belirtilen rollere ek olarak nasıl roller olabilir? Neden?
13. Örnek ders planı incelerken ve ders planı oluştururken, görev aldığınız rolü ne derecede gerçekleştirdiğinizi düşünüyorsunuz? Nasıl, açıklar mısınız?
14. Görev aldığınız rol ile ilgili ne/neler hoşunuza gitti? Neden?
15. Görev aldığınız rol ile ilgili karşılaştığınız zorluklar nelerdir? Neden?
16. Çevrimiçi uygulama topluluğunda, ders planı inceleme, oluşturma ve uygulama sonrası paylaşım etkinliklerinde etkileşim nasıldı?
    - Niceliği açısından? Niceliğini (i) olumlu ve (ii) olumsuz neler etkilemiş olabilir? Neden? Bu durum sizi nasıl etkiledi?
    - Kalitesi ya da tartışmaya sağladığı katkı açısından? Kalitesini (i) olumlu ve (ii) olumsuz neler etkilemiş olabilir? Neden? Bu durum sizi nasıl etkiledi?
17. Tartışma etkinliklerinde, etkileşimin kalitesini/tartışmaya sağladığı katkıyı arttırmak için neler yapılabilirdi?
18. Bu çevrimiçi eğitim programının, teknolojinin bilişsel araç olarak kullanımı konusunda daha etkili bir öğretmen eğitimi programı olması için neler yapılabilir?

D. An Example of Data Analysis Process of Interview Data

1. The following steps were followed for analysis of the interview data.

2. Codes were identified throughout the data. A set of sample codes within the category of communication is as follows:

Initial codes	Related category	Related theme	Main theme
Scheduling routine meetings within small groups	Communication	Interaction between teachers	Maintaining online CoP
Informing the participants about the activities in the LMS			
Synchronous sessions after each activity			
Asynchronous communication			

3. The codes were grouped into categories and then themes.

4. The data was interpreted through the emergent categories and themes.

E. The Criteria for Evaluating the Indicators of Technology Integration as Cognitive Tools in the Lesson Plans based on Jonassen's Designing Constructivist Learning Environments Model (1999)

1. Question/Case/Problem/Project

1.1. Is the lesson plan designed with a focus of a problem that learners attempt to solve or resolve?

- A problem constituting a learning goal that students may accept or adapt
- Students learn domain content to solve the problem

1.2. Is the problem ill-defined or ill-structured?

Jonassen (1997) mentioned the characteristics of ill-structured problems as follows:

- Have unstated goals and constraints
- Possess multiple solutions, solution paths, or no solutions at all
- Possess multiple criteria for evaluating solutions
- Present uncertainty about which concepts, rules, and principles are necessary for the solution or how they are organized
- Offer no general rules or principles for describing or predicting the outcome of most cases
- Require learners to make judgement about the problem and to defend their judgements by expressing personal opinions or beliefs.

1.3. Is the problem authentic that contains tasks replicating the particular activity structures of a context?

- Problems which present the same type of cognitive challenges as those in the real world (Honebein, Duffy, & Fishman, 1993, Savery & Duffy, 1996).

1.4. Is the problem given with its context?

- A story about a set of events that leads up to the problem that needs to be resolved
- Description of the physical, socio-cultural, and organizational climate surrounding the problem

1.5. Is the problem represented to the learners in an interesting, engaging, and appealing way?

- Problems personally relevant or interesting to the learner
- Problem presentation simulating the problem in a natural context

1.6. Do the activities contain problem manipulation spaces that enable learners to test the effects of their manipulations?

- Learners manipulate something (Construct a product, manipulate parameters, make decisions) and affect the environment in some way
- Causal models that enable students to test the effects of the manipulations

2. Related Cases

2.1. Does the lesson plan provide related cases or worked examples to enable case-based reasoning and enhance cognitive flexibility?

- Provide a set of related experiences to which novice student can refer.
    - Scaffolding memory/Case-based reasoning: Provide a similar case, help students map the previous experience and its lessons onto the current problem.
    - Enhancing cognitive flexibility: Provide a variety of viewpoints and perspectives on the case or project being solved.

3. Information Resources

3.1. Does the lesson plan provide learner-selectable information just-in-time?

- Provide the information that learners need to interpret the problem
    - In problem representation
    - As extra resources (Text documents, graphics, sound resources, video, animations, websites)

3.2. Do the lesson activities include relevant information?

- Provide hints within the lesson plan
- Provide related resources

3.3. Do the lesson activities include accessible information?

- Ensure students access to the relevant resources (Ex: ICT teacher as an expert, Mathematics teacher as an expert)

4. Cognitive Tools

4.1. Do the lesson activities provide learners tasks that require cognitive tools to design and build artefacts?

- Involve learners in designing and building a product with the help of a cognitive tool

4.2. Do the lesson activities provide learners tasks that require cognitive tools to organize and represent what they already know?

- Help learners to articulate and represent what they know

4.3. Do the lesson activities provide learners tasks to negotiate meaning through cognitive tools?

- Support learners' internal negotiations and meaning making

4.4. Do the lesson activities provide learners cognitive tools to transcend the limitations of their minds, such as limitations to memory, thinking, or problem solving?

- Engage learners in new forms of thinking
- Extend the thinking process
- Enable new forms of knowledge representation and task manipulation

4.5. Do the lesson activities provide learners cognitive tools to scaffold their thinking?

- Engage learners in deeper levels of thinking and reasoning, such as causal, analogical, expressive, experiential, and problem solving

4.6. Do the lesson activities provide learners tasks to reflect on the activity through cognitive tools?

- Make learners reflect on what they have learned and how they came to know it

5. Conversation/Collaboration Tools

5.1. Do the lesson activities provide conversation and collaboration tools to support discourse communities, knowledge-building communities, and/or communities of learners?

- Support:
    - collaboration within a group of participants
    - shared decision making about how to manipulate the environment
    - alternative interpretations of topics and problems
    - articulation of learners’ ideas
    - reflection on the processes they used

6. Social/Contextual Support

6.1. Do the lesson activities provide social/contextual support for the learning environment?

- Accommodate environmental and contextual factors for implementation

  (Ex: Involving ICT teacher in the implementation since teachers are not competent enough in the use of cognitive tool, Planning the mathematics lesson in the computer lab)

- Provide pretraining of the teachers about the tool
- Provide pretraining of the students about the tool
- Incorporate ICT teachers into the planning process

7. Instructional Activities

7.1. Are there any activities that requires teachers' modeling?

- Model performance (Showing how to perform, worked examples)
- Articulate reasoning (Showing the reasoning and decision making in each step, how to develop arguments to support the solutions)

7.2. Are there any activities that requires teachers' coaching?

- Providing motivational prompts
- Monitoring and regulating the learners’ performance
    - Provide hints and helps
    - Prompt appropriate kinds of thinking

  - Prompt the use of collaborative activities
  - Prompt consideration of related cases or information resources that may help learners interpret or understand ideas
  - Prompt the use of specific cognitive tools
  - Provide feedback informing the learners about the effectiveness and accuracy of their performance and analyzing their actions and thinking
- Provoking reflection by asking the learners to:
  - Reflect on what they have done
  - Reflect on what assumptions they made
  - Reflect on what strategies they used
  - Explain why they made a particular response or tool an action
  - Confirm an intended response
  - State how certain they are in a response
  - Involve in arguing with the coach
  - Solve puzzles (provided by the teacher) which will lead to appropriate performance
- Perturbing learners' models
  - Embed provoking questions
  - Reflect on actions they have taken
  - Ask learners to confirm or clarify what did happen
  - Provide dissonant views or interpretations

7.3. Are there any activities that requires teachers' scaffolding?

- Adjusting task difficulty
  - Start the learners with the tasks they know how to perform and gradually add task difficulty until they are unable to perform alone
- Restructuring a task to supplant knowledge
  - Redesign the task in a way that supports learning

    - Suggest or impose the use of cognitive tools to help learners represent or manipulate the problem

- Providing alternative assessments
    - The project or problem requirements are clearly communicated, so that learners understand what will be required of them.

F. A Sample Analysis of the Lesson Plans

Teknolojinin Bilişsel Araç Olarak Kullanımına Yönelik Ders Planı

A. Ders Planının Künyesi

Grup adı: 3. Grup
Sınıf seviyesi: 6
Ünite/Tema Adı: M.6.1 Sayılar ve İşlemler
Alt Öğrenme Alanı: M.6.1.6 Ondalık Gösterim
Kazanımlar:
M.6.1.6.3. Ondalık gösterimleri verilen sayıları belirli bir basamağa kadar yuvarlar.
Sayıları yuvarlamanın sağladığı kolaylıklar üzerinde durulur.

Materyaller:
Bilgisayar (Her öğrenci için)
Scratch
Zoom Programı
Etkinlik Kağıdı

Gerekli ön bilgi:
Bu yıl aşağıdaki kazanımlar daha önce ele alınmalıdır.
M.6.1.6.2. Ondalık gösterimleri verilen sayıları çözümler.

Öğretim yöntemleri:
Problem çözme, soru – cevap tekniği, keşfetme.

Öğrenme çıktıları:
Bu ders planının sonunda öğrencinin Scratch'te ondalık sayıları çözümleme becerilerini de kullanarak bir programlama yapması beklenmektedir. Bu üründe, öğrenci ondalık gösterimleri verilen sayıları yuvarlama ile ilgili bildiklerini kullanarak bir ürün yaratacaktır. Öğrencilerin bir ondalık sayıyı istenen basamağa göre yuvarlarken dikkat etmeleri gereken adımları belirlemeleri ve bunu yazdıkları kodlamada kullanmaları beklenmektedir.

> **Dicle Çolpan**
> 4.2. Do the lesson activities provide learners tasks that require cognitive tools to organize and represent what they already know?
> Yes:
> -Helping learners to articulate and represent what they know
>
> In this lesson plan, students are expected to use their prior knowledge about writing decimals in the expanded forms while building their games for rounding.
> 19 Haziran 2022, 17:30
> Yanıtla

Öğrenme çıktıları:
Bu ders planının sonunda öğrencinin Scratch'te ondalık sayıları çözümleme becerilerini de kullanarak bir programlama yapması beklenmektedir. Bu üründe, öğrenci ondalık gösterimleri verilen sayıları yuvarlama ile ilgili bildiklerini kullanarak bir ürün yaratacaktır. Öğrencilerin bir ondalık sayıyı istenen basamağa göre yuvarlarken dikkat etmeleri gereken adımları belirlemeleri ve bunu yazdıkları kodlamada kullanmaları beklenmektedir.

Hedef kitle:
Öğrenciler 11-12 yaşlarında 6.sınıf öğrencileridir. Piaget'nin Bilişsel Gelişim Dönemlerine göre soyut işlemler döneminde (11 yaş ve yukarısı) yer alırlar. Bu dönemde öğrenciler, soyut düşünme, bilimsel düşünme, göreceli düşünme, hipotetik düşünme, akıl yürütme, birleştirici düşünme, birleştirici düşünme, ileriye/geriye doğru düşünme ve analoji gibi bilişsel işlemleri gerçekleştirebilirler.

Öğrenme ortamı:
Bu ders, online ortamda gerçekleşeceği için her öğrenci kendi bilgisayarı ile zoom programı üzerinden ders katılır. Scratch'e tarayıcı üzerinden erişilebilir ve her

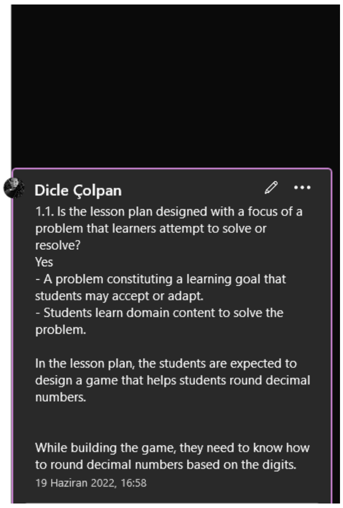
> **Dicle Çolpan**
> 4.5. Do the lesson activities provide learners cognitive tools to scaffold their thinking?
> Yes:
> -Engaging learners in deeper levels of thinking and reasoning, such as causal, analogical, expressive, experiential, and problem solving.
>
> In this lesson plan, while solving their problem about developing a game for rounding decimals, students are expected to engage in deeper levels of thinking and reasoning.
> 19 Haziran 2022, 17:33
> Yanıtla

öğrencinin hesabının önceden oluşturması ve bu hesap üzerinden proje dosyasını paylaşması istenir.

Derse bağlandıktan sonra ise etkinlik kağıdı ekranda paylaşılmalıdır.

C. Yapılandırmacı Öğrenme Ortamı Tasarımı İlkelerinin (Jonassen, 1999) Uygulaması

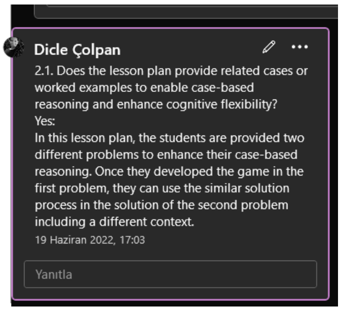
Öğrenme hedeflerine uygun bir problem durumu
Bu ders planında, öğrencilerin ondalık sayıları yuvarlama ile ilgili öğrendikleri kuralları uygulayarak, Scratch'te bir program yazmaları ve ilgili programın çalıştığını gözlemlemeleri beklenmektedir.
Öğrenciler, daha önceki kazanımlardaki ondalık sayıları çözümleme bilgilerini de kullanarak ilgili kodlamayı yapabileceklerdir.



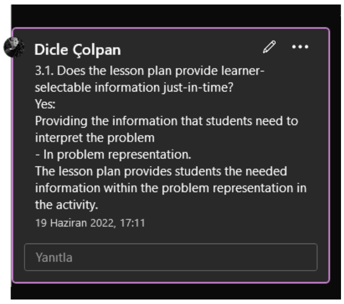
İlişkili durumlar
Öğrenciler dersin giriş bölümünde, market alışverişinde karşılaştıkları ondalık sayılar ve kasada ödeyecekleri tahmin ederken kullandıkları yuvarlama işlemini keşfedeceklerdir. Konu ile ilgili paylaşılan videoda da yuvarlama işlemine neden gerek duyulduğu ile ilgili örnekler hakkında bilgi edineceklerdir. Etkinliğin son bölümünde, yine market alışverişi örneği ele alınacaktır.

Değerlendirme bölümünde ise bir yolun belirli noktalarında bulunan benzin istasyonlarına olan yakınlığı ondalık sayılarda yuvarlama işlemi ile ilişkilendireceklerdir. Bölüşülen bir paranın yaklaşık kaç ₺ ye denk geldiğini tahmin edeceklerdir.

Bu şekilde, benzer çözüm yollarını uygulayabilecekleri farklı örnekler ele alacaklardır.



İhtiyaç duyulan bilgi kaynakları
Öğrencilerle problemin çözümü için gerekli olan bilgiler etkinlik kağıtlarında paylaşılır. Scratch ile ilgili ön hazırlıklar Bilişim Teknolojileri ve Yazılım dersinde yapılmıştır. Desteğe ihtiyaç duyan öğrencilere BT ve Matematik öğretmeni tarafından gerekli destek sağlanır.



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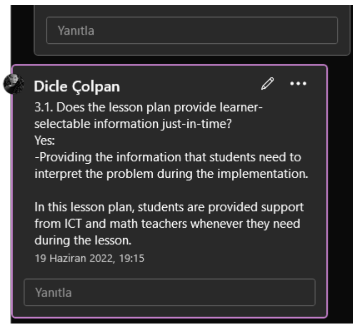
Bilişsel araçlar
Öğrencilerin verilen etkinlik kağıdında öğrendiklerini aktaracakları bilişsel araç Scratch'tir. Bu bilişsel araçla, öğrenciler verilen kodlamayı yapabilmek için ondalık sayıları yuvarlama ile ilgili öğrendikleri bilgileri kullanacaklardır. Daha sonra geliştirdikleri programı test edeceklerdir.



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İletişim ve iş birliği ortamı
Öğrencilerin iş birliği içinde çalışabilecekleri, birbiriyle etkileşime girebilecekleri ve iletişim kurabilecekleri ortamlar sağlanır.

Dicle Çolpan
5.1. Do the lesson activities provide conversation and collaboration tools to support discourse communities, knowledge-building communities, and/or communities of learners?
Yes:
-Supporting
*collaboration within a group of participants
*shared decision making about how to manipulate the environment
*alternative interpretations of topics and problems
*articulation of learners' ideas
*reflection on the processes they used.

In this lesson plan, the activities in part II and III are pair activities. The lesson is conducted via Zoom. For collaborative activities, breakout rooms feature is used.
19 Haziran 2022, 21:33

yapılmıştır. Desteğe ihtiyaç duyan öğrencilere BT ve Matematik öğretmeni tarafından gerekli destek sağlanır.

Bilişsel araçlar
Öğrencilerin verilen etkinlik kağıdında öğrendiklerini aktaracakları bilişsel araç Scratch'tir. Bu bilişsel araçla, öğrenciler verilen kodlamayı yapabilmek için ondalık sayıları yuvarlama ile ilgili öğrendikleri bilgileri kullanacaklardır. Daha sonra geliştirdikleri programı test edeceklerdir.

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Öğrenme ortamı için sosyal ve bağlamsal destek
Scratch ile ilgili ön hazırlıklar yapılmıştır. Desteğe ihtiyaç duyan öğrencilere BT ve Matematik öğretmeni tarafından gerekli destek sağlanır.

Dicle Çolpan
6.1. Do the lesson activities provide social/contextual support for the learning environment?
Yes:
-Accommodating environmental and contextual factors for implementation
(Ex: Involving ICT teacher in the implementation since teachers are not competent enough in the use of cognitive tool, Planning the mathematics lesson in the computer lab)
-Pretraining of the teachers about the tool
-Pretraining of the students about the tool
-Integrating ICT teachers into the planning process

In this lesson plan, students take pretraining related to the cognitive tool. Also, ICT teachers provide support for mathematics teachers about the tool and planning. Students are provided support during the implementation.
19 Haziran 2022, 21:36

D. Dersin Akışı

Giriş:

Dersin girişinde öğrencilere bir markette alışveriş yaparken ürün fiyatlarında denk geldikleri ondalık sayılar sorulur ve yanıtlar toplanır. Ardından öğrencilere, aldıkları birkaç ürün olduğunda ve her birinin ondalık gösterimle belirtilmiş fiyatları olduğunda, kasaya gelmeden önce yaklaşık ne kadar ödeyeceklerini nasıl hesapladıkları sorulur. Yanıtlar alındıktan sonra, neden ondalık sayıları yuvarlamaya ihtiyaç duyulduğundan bahsedilir ve aşağıdaki videonun 03:07'ye kadar olan bölümü izlenir.

https://youtu.be/fd-E18EqSVk

Dicle Çolpan
1.4. Is the problem given with its context?
Yes:
- A story about a set of events that leads up to the problem that needs to be resolved
- Description of the physical, socio-cultural, and organizational climate surrounding the problem

In the lesson plan, the need for rounding in daily life is given with the story. The shopping experience at a market is reminded to the students. Then the students are expected to work on the problem which is designing a game that helps rounding.
19 Haziran 2022, 19:23
Yanıtla

D. Dersin Akışı

Giriş:

Dersin girişinde öğrencilere bir markette alışveriş yaparken ürün fiyatlarında denk geldikleri ondalık sayılar sorulur ve yanıtlar toplanır. Ardından öğrencilere, aldıkları birkaç ürün olduğunda ve her birinin ondalık gösterimle belirtilmiş fiyatları olduğunda, kasaya gelmeden önce yaklaşık ne kadar ödeyeceklerini nasıl hesapladıkları sorulur. Yanıtlar alındıktan sonra, neden ondalık sayıları yuvarlamaya ihtiyaç duyulduğundan bahsedilir ve aşağıdaki videonun 03:07'ye kadar olan bölümü izlenir.

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Gelişme:
Ondalık sayılarla yuvarlama işleminin ilgili basamağa göre nasıl yapıldığı anlatılır. Ardından öğrencilerle etkinlik dosyası paylaşılır.

Bölüm-I'de tüm sınıfın katılımıyla soru cevaplarla ilgili problem değerlendirilir ve

Dicle Çolpan
1.5. Is the problem represented to the learners in an interesting, engaging, and appealing way?
Yes:
- Problems personally relevant or interesting to the learner
- Problem presentation simulating the problem in a natural context

In the introduction part, students are provided a relevant and interesting daily life situation. The need for rounding is highlighted. An interesting video is used about rounding.
19 Haziran 2022, 19:18
Yanıtla

Gelişme:
Ondalık sayılarla yuvarlama işleminin ilgili basamağa göre nasıl yapıldığı anlatılır. Ardından öğrencilerle etkinlik dosyası paylaşılır.

Dicle Çolpan
3.1. Does the lesson plan provide learner-selectable information just-in-time?
Yes:
Providing the information that students need to interpret the problem at the beginning of the problem representation.
19 Haziran 2022, 17:14
Yanıtla

Gelişme:
Ondalık sayılarla yuvarlama işleminin ilgili basamağa göre nasıl yapıldığı anlatılır. Ardından öğrencilerle etkinlik dosyası paylaşılır.

Dicle Çolpan
3.2. Do the lesson activities include relevant information?
Yes:
- Providing explanation related with the problem
- Providing related resources
19 Haziran 2022, 17:15
Yanıtla

Gelişme:

Ondalık sayılarla yuvarlama işleminin ilgili basamağa göre nasıl yapıldığı anlatılır. Ardından öğrencilerle etkinlik dosyası paylaşılır.

Bölüm-I'de tüm sınıfın katılımıyla soru cevaplarla ilgili problem değerlendirilir ve ilgili soruların yanıtları tartışılarak belirlenir. BT öğretmeni, ihtiyaç halinde öğrencilerle ipuçları paylaşabilir.

Bölüm-II ve Bölüm-III'te öğrencilere Zoom'da gruplara (Breakout rooms) ayrılacakları ve ikili gruplar halinde çalışacakları belirtilir. BT ve Matematik öğretmeni gruplar arasında dolaşarak, desteğe ihtiyaç duyan öğrencilere yardımcı olur.

> **Dicle Çolpan**
> 3.3. Do the lesson activities include accessible information?
> Yes:
> - Ensuring students access to the relevant resources such as mathematics and ICT teachers as experts, related documents, and pretraining of the tool before the implementation of the lesson plan
> 19 Haziran 2022, 17:19
> Yanıtla

Ardından öğrencilerle etkinlik dosyası paylaşılır.

Bölüm-I'de tüm sınıfın katılımıyla soru cevaplarla ilgili problem değerlendirilir ve ilgili soruların yanıtları tartışılarak belirlenir. BT öğretmeni, ihtiyaç halinde öğrencilerle ipuçları paylaşabilir.

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Bölüm-II ve Bölüm-III için ayrılan süre tamamlandığında, ana gruba dönülür ve öğrencilerle yaptıkları çalışmaların üzerinden geçilir. Kodladıkları Scratch projelerinin linklerini e-posta yoluyla paylaşmaları istenir.

Bölüm-IV'te öğrencilere tekrar ikili gruplar halinde çalışacakları belirtilir. BT ve Matematik öğretmeni gruplar arasında dolaşarak, desteğe ihtiyaç duyan öğrencilere yardımcı olur.

> **Dicle Çolpan**
> 7.2. Are there any activities that requires teachers' coaching?
> Yes:
> - Providing motivational prompts
> -Monitoring and regulating the learners' performance
>
> In this lesson plan, the teacher provokes students' reflection by asking the their understanding of the problem, perturb their models. While they are sharing their ideas about solutions, hints are shared with them.
>
> Also, mathematics and ICT teachers monitor and regulate their performance throughout the lesson.
> 19 Haziran 2022, 22:30
> Yanıtla

Bölüm-II ve Bölüm-III'te öğrencilere Zoom'da gruplara (Breakout rooms) ayrılacakları ve ikili gruplar halinde çalışacakları belirtilir. BT ve Matematik öğretmeni gruplar arasında dolaşarak, desteğe ihtiyaç duyan öğrencilere yardımcı olur.

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Bölüm-IV'te öğrencilere tekrar ikili gruplar halinde çalışacakları belirtilir. BT ve Matematik öğretmeni gruplar arasında dolaşarak, desteğe ihtiyaç duyan öğrencilere yardımcı olur.

Örnek Scratch Projesi

https://scratch.mit.edu/projects/473018696/editor/

> **Dicle Çolpan**
> 7.3.Are there any activities that requires teachers' scaffolding?
> Yes:
> -Adjusting task difficulty
> o Start the learners with the tasks they know how to perform and gradually add task difficulty until they are unable to perform alone
> - Restructuring a task to supplant knowledge
> o Redesigning the task in a way that supports learning
> o Suggesting or imposing the use of cognitive tools to help learners represent or manipulate the problem
> - Providing alternative assessments
> o The project or problem requirements are clearly communicated, so that learners understand what will be required of them.
>
> In this lesson plan, students are provided support to help them perform the task. The problem requirements are clearly stated at the beginning.
> 19 Haziran 2022, 22:25
> Yanıtla

Etkinlik Kağıdı

Ondalık Sayıları Yuvarlayalım: Bir Scratch Projesi

Bu etkinlikte Scratch ile bir program yazmanız beklenmektedir. Bu programda,

- onlar, birler, ondabirler, yüzdebirler ve bindebirler basamakları olan bir ondalık sayının kullanıcı tarafından belirlenmesi ve
- belirlenen sayının onlar, birler, ondabirler ve yüzdebirler basamağına yuvarlanması sonucu oluşan sayının kullanıcının ilgili butonlara basmasıyla hesaplanması
- hesaplanan değerlerin ekranda gösterilmesi

beklenmektedir.

Bölüm-I

1. Girdiğiniz bir ondalık sayının belirtilen basamağa göre yuvarlanmasının sonucunu gösteren bir program yazmak için, Scratch'te programın hangi

> **Dicle Çolpan**
> 4.1. Do the lesson activities provide learners tasks that require cognitive tools to design and build artefacts?
> Yes:
>
> - Designing and building a product with the help of a cognitive tool
> In this lesson plan, students are expected to program a game that indicates the rounding of the given decimal numbers based on the digits.
> 19 Haziran 2022, 17:24
> Yanıtla

Etkinlik Kağıdı

Ondalık Sayıları Yuvarlayalım: Bir Scratch Projesi

Bu etkinlikte Scratch ile bir program yazmanız beklenmektedir. Bu programda,

- onlar, birler, ondabirler, yüzdebirler ve bindebirler basamakları olan bir ondalık sayının kullanıcı tarafından belirlenmesi ve
- belirlenen sayının onlar, birler, ondabirler ve yüzdebirler basamağına yuvarlanması sonucu oluşan sayının kullanıcının ilgili butonlara basmasıyla hesaplanması
- hesaplanan değerlerin ekranda gösterilmesi beklenmektedir.

Bölüm-I

1. Girdiğiniz bir ondalık sayının belirtilen basamağa göre yuvarlanmasının sonucunu gösteren bir program yazmak için, Scratch'te programın hangi eylemleri gerçekleştirmesi gerekir?

2. Bu eylemlerin arasında bir sıralama var mı? Neden?

Bölüm-II: Scratch ile Kodlayalım

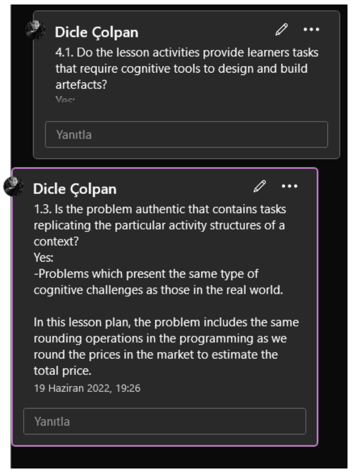
3. Belirlenecek ondalık sayının her basamağının sürgü ile seçilmesini sağlayın.
4. Programda onlar, birler, ondabirler ve yüzdebirler basamaklarına yuvarlama işlemlerini gerçekleştiren kuklalar (Butonlar) tasarlayın. Bu kuklaların üzerine ilgili yuvarlamayı hangi basamağa göre gerçekleştireceğini yazın. (Ör: "Onlar bs. yuvarlayalım")
5. Programda ilgili butonlar tıklandığında, yapılacak işlemleri kodlayın.
6. Sonucun butonun yanında gösterilmesini sağlayın.

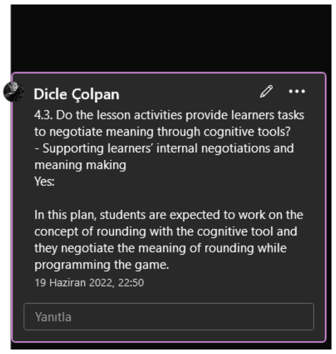
Bölüm-II: Scratch ile Kodlayalım

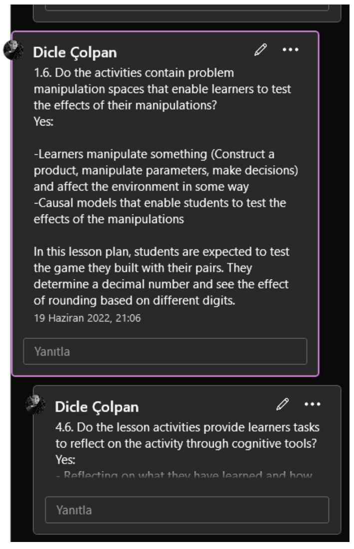
3. Belirlenecek ondalık sayının her basamağının sürgü ile seçilmesini sağlayın.
4. Programda onlar, birler, ondabirler ve yüzdebirler basamaklarına yuvarlama işlemlerini gerçekleştiren kuklalar (Butonlar) tasarlayın. Bu kuklaların üzerine ilgili yuvarlamayı hangi basamağa göre gerçekleştireceğini yazın. (Ör: "Onlar bs. yuvarlayalım")
5. Programda ilgili butonlar tıklandığında, yapılacak işlemleri kodlayın.
6. Sonucun butonun yanında gösterilmesini sağlayın.

Bölüm-III: Programı test edelim

7. Grup arkadaşınız ile bir sayı belirleyin ve yazdığınız programı test edin.
8. Belirlediğiniz sayı nedir?
9. Belirlediğiniz sayıyı
   a. Onlar basamağına göre yuvarladığınızda ne buldunuz?
   b. Birler basamağına göre yuvarladığınızda ne buldunuz?







Bölüm-III: Programı test edelim

7. Grup arkadaşınız ile bir sayı belirleyin ve yazdığınız programı test edin.

8. Belirlediğiniz sayı nedir?

9. Belirlediğiniz sayıyı
   a. Onlar basamağına göre yuvarladığınızda ne buldunuz?

   b. Birler basamağına göre yuvarladığınızda ne buldunuz?

Dicle Çolpan
4.6. Do the lesson activities provide learners tasks to reflect on the activity through cognitive tools?
Yes:
- Reflecting on what they have learned and how they came to know it
In this lesson plan, the students are expected to think about the concept of rounding, program a game to do the operations, and test it whether it works properly or not.

The following part help students reflect on the problem by rounding the decimals which they learned.
19 Haziran 2022, 22:44

6. Sonucun butonun yanında gösterilmesini sağlayın.

Bölüm-III: Programı test edelim

7. Grup arkadaşınız ile bir sayı belirleyin ve yazdığınız programı test edin.

8. Belirlediğiniz sayı nedir?

9. Belirlediğiniz sayıyı
   a. Onlar basamağına göre yuvarladığınızda ne buldunuz?

   b. Birler basamağına göre yuvarladığınızda ne buldunuz?

Dicle Çolpan
4.4. Do the lesson activities provide learners cognitive tools to transcend the limitations of their minds, such as limitations to memory, thinking, or problem solving?
Yes:
-Engaging learners in new forms of thinking
-Extending the thinking process
-Enabling new forms of knowledge representation and task manipulation

In this lesson plan, students used the game they designed to round the decimal numbers without doing the necessary operations by themselves each time.
19 Haziran 2022, 17:46

Bölüm-IV: Problem çözelim

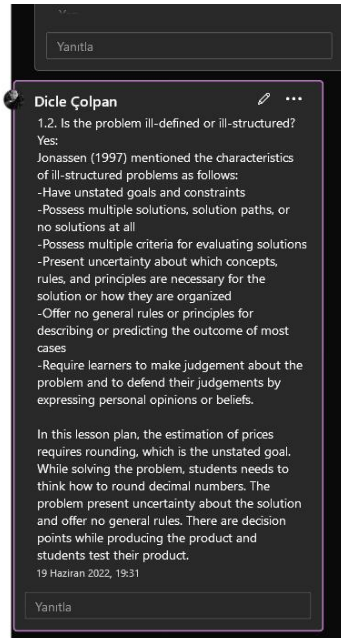
10. Aşağıdaki broşürde bazı ürünlerin fiyatları verilmiştir. Markette uygulanan bir kampanyaya göre ürünlerin fiyatları en yakın ondabirler basamağına yuvarlanmaktadır.

a) Bu doğrultuda, kampanyaya göre hangi ürünler alınırsa karlı bir alışveriş yapılmış olur?

Dicle Çolpan
4.6. Do the lesson activities provide learners tasks to reflect on the activity through cognitive tools?
Yes:
- Reflecting on what they have learned and how they came to know it
In this lesson plan, the students are expected to think about the concept of rounding on a real life context and decide which one is more profitable.
19 Haziran 2022, 17:38

Yanıtla

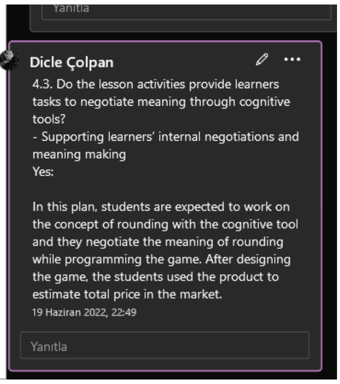
Dicle Çolpan
1.2. Is the problem ill-defined or ill-structured?
Yes:



a) Bu doğrultuda, kampanyaya göre hangi ürünler alınırsa karlı bir alışveriş yapılmış olur?

b) Broşürdeki tüm ürünlerden birer tane/paket alındığında, ilgili kampanyayı göz önüne alarak kaç ₺ ödenir?

c) Kasaya gitmeden önce birler basamağına yuvarlayarak ortalama bir tahminde bulunulursa, kaç ₺ ödeneceği tahmin edilir?



a) Bu doğrultuda, kampanyaya göre hangi ürünler alınırsa karlı bir alışveriş yapılmış olur?

b) Broşürdeki tüm ürünlerden birer tane/paket alındığında, ilgili kampanyayı göz önüne alarak kaç ₺ ödenir?

c) Kasaya gitmeden önce birler basamağına yuvarlayarak ortalama bir tahminde bulunulursa, kaç ₺ ödeneceği tahmin edilir?

Değerlendirme:

Öğrencilerin aşağıdaki soruları bireysel olarak çözmeleri ve yanıtlarını Mentimeter vb. bir web 2.0 aracıyla paylaşmaları istenir.

- 189.99₺ olan bir kazağı 10 kişi paylaşarak hediye alacaklardır. Kişi başına yaklaşık kaç ₺ düşer?
  A) 190 B)189 C) 18 D) 19

- İki şehir arasındaki bir yolun her ondabirlik bölümünün bitiminde bir benzin istasyonu bulunmaktadır. Yolun 0,789'unu tamamlamış birisi, benzin uyarısı aldığında en yakın istasyon olarak neredeki benzin istasyonunu tercih etmelidir?
  A) 0,6 B) 0,7 C)0,8 D)0,9

Ondalık Sayıları Yuvarlayalım: Bir Scratch Projesi

Öğretmen Rehberi

Bölüm-I

1. Girdiğiniz bir ondalık sayının belirtilen basamağa göre yuvarlanmasının sonucunu gösteren bir program yazmak için, Scratch'te programın hangi eylemleri gerçekleştirmesi gerekir?

    - Kullanıcı tarafından ondalık sayının her basamağının girdi olarak alınması
    - Onlar, birler, ondabirler ve yüzdebirler basamağına göre yuvarlama işlemini yapacak butonların belirlenmesi
    - Butonların arka planda gerçekleştirecekleri işlemlerin kodlanması
    - Yapılan işlemlerin sonucunun gösterilmesi

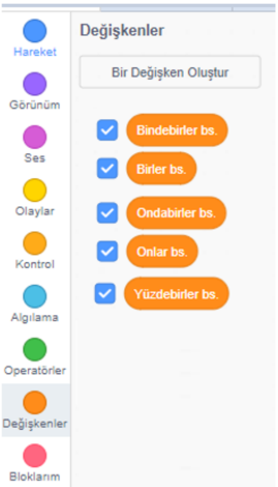
2. Bu eylemlerin arasında bir sıralama var mı? Neden?

    Evet, bu işlemler arasında bir sıralama bulunmaktadır. Çünkü öncelikle yuvarlama işlemini yapacağımız sayıyı belirlemek gerekir. Ardından onu hangi basamağa göre yuvarlamak istiyorsak, o basamaklar için ilgili işlemleri yapacak butonları tasarlamamız gerekir. Son olarak da butonların ilgili işlemi yapmasını ve sonucu göstermesini sağlamamız gerekir.

Bölüm-II

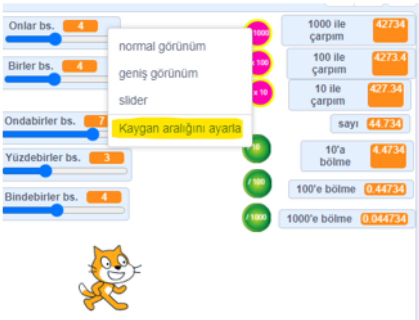
3. Ondalık sayının girdi olarak alınması

Ondalık sayıyı programda belirlerken, onlar, birler, ondabirler, yüzdebirler ve bindebirler basamaklarını seçmek için; her biri için bir değişken tanımlamamız gerekir.



Her bir değişkenin üzerine sağ tıklayarak slider görünümünü seçeriz. Böylece, ilgili değişkenlerimizi ekranda sürgü ile belirleyebiliriz.

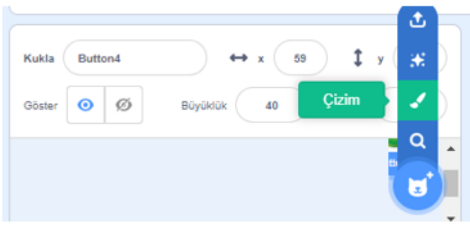
Her basamağı sürgü ile seçebilir hale geldikten sonra, sliderı 0 ile 9 arasında seçilebilir yapmaları gerektiği hatırlatılır.



4. Programda onlar basamağı, birler basamağı, ondabirler ve yüzde birler basamağına göre yuvarlama işlemlerini tetikleyen butonların kukla olarak tasarlanması

   4 tane buton kukla olarak tasarlanır. Her birinin içine hangi işlemi yapmaya yönelik olduğu yazılır.

   Sağ alt köşede yer alan kukla ekle butonu yardımıyla çizim seçeneği seçilir ve her işlemi gösteren butonlar tasarlanır.



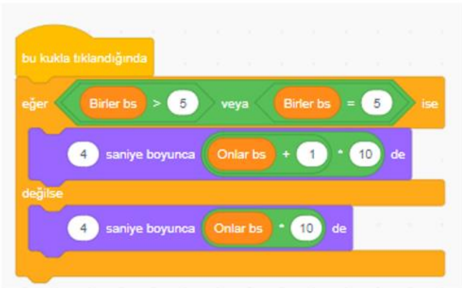
5-6. Sorular

Programda butonların ilgili basamağa göre yuvarlama işlemlerini yapmasının kodlanması

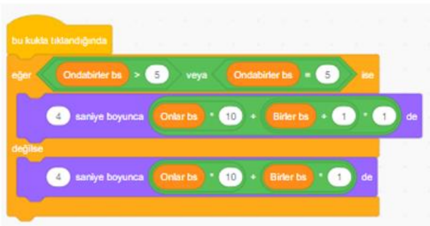
Her bir kuklaya tıklandığında, ilgili sonucu hangi işlemi yaparak bulacağı kodlanır. Burada öğrencilerin kodlama sırasında aşağıdaki matematik bilgilerini kullanmaları beklenmektedir.

- Bir sayıyı hangi basamağa kadar yuvarlayacaksak, o basamağın bir sağındaki basamakta yer alan rakam belirlenir.
- Eğer belirlenen rakam 5'ten büyükse, yuvarlamak istediğimiz basamaktaki rakamın bir büyüğü yazılır ve basamak değerine göre yuvarlanmış sayı belirlenir.
- Eğer belirlenen rakam 5'ten küçükse, yuvarlamak istediğimiz basamaktaki rakam olduğu gibi yazılır ve basamak değerine göre yuvarlanmış sayı belirlenir.
- Bir sayıyı basamaklarına göre çözümleyebilir.
  Ör: 12,783 = 1.10 + 2.1 + 7. 0,1 + 8. 0,01 + 3. 0,001

Onlar basamağına yuvarlayalım butonu:



Birler basamağına yuvarlayalım butonu:



Ondabirler basamağına yuvarlayalım butonu:

G. The Roles within the Online CoP

Çevrimiçi Uygulama Topluluğunda Roller

Öncü/Lider (Starter/Leader)

Küçük çalışma grubunda, iş birliğiyle yürütülecek çalışmalarda, öncü/lider rolünü üstlenen katılımcının aşağıdaki sorumlulukları olacaktır:

- İlk olarak verilen görevi analiz eder ve kendi görüşünü paylaşır.
- Ele alınması gereken yeni noktaları ekler.

Örnek:

- Bu çalışmada bizden ……. hususlarını değerlendirmemiz isteniyor. Buna göre, ben ….. düşünüyorum. Sizin görüşleriniz nelerdir?
- Aynı zamanda, … konusunu da ele almalıyız.

Moderatör (Facilitator)

Bu çalışmada, küçük çalışma grubunda ve tüm katılımcıların yer aldığı grupta, moderatör rolünü eğitimi planlayan üstlenecektir ve aşağıdaki sorumlulukları olacaktır:

- İlgili öğrenme etkinliklerini, bilgilendirmeleri ve materyalleri paylaşır.
- Paylaşımları yakından takip eder.
- Paylaşımlarda yer alan görüşleri, fikirleri detaylandırmak ve anlaşılmasını sağlamak için kritik sorular yöneltir.
- Katılımı teşvik eder.

Zaman Tutucu (Timer)

Küçük çalışma grubunda, iş birliğiyle yürütülecek çalışmalarda, zaman tutucu rolünü üstlenen katılımcının aşağıdaki sorumlulukları olacaktır:

- Öğrenme etkinlikleri çerçevesinde paylaşımların ve tartışmaların süresini takip eder ve gerekli hatırlatmaları yapar.
- Öğrenme etkinlikleri çerçevesinde takip edilmesi gereken adımları ve süreyi gözetir.

Örnek:

- Bu etkinlik için toplamda ayrılan süre, … kadar. Değerlendirilmesi gereken diğer noktalar ise, ……. Bu konuda bir karara varıp, …'ya geçebiliriz.

Raporlayan (Reporter)

Küçük çalışma grubunda, iş birliğiyle yürütülecek çalışmalarda, raporlayan rolünü üstlenen katılımcının aşağıdaki sorumlulukları olacaktır:

- Verilen görevin son halini tüm gereklilikleri kontrol eder ve grup içinde raporlar.
- Büyük gruba, küçük grupta yapılan çalışmaları grubun sözcüsü olarak raporlar.

Örnek:

- Ele aldığımız tüm noktaları, ders planına işledik. İstenen …. noktanın ise, eksik kaldığını görüyoruz. Bu bölümde ne yapabiliriz?
- Bizim grubumuzda, ders planımız … kazanımlarına yönelikti.

NOTLAR:

1. Tüm öğrenme etkinliklerinde, katılımcıların iş birliği içinde çalışması beklenmektedir. Roller, sadece çevrimiçi uygulama topluluğunun yürütülmesine ilişkindir. Her etkinlikte, çevrimiçi uygulama topluluğuna tüm katılımcılar katkı sunmalıdır.
2. Roller, öğrenme etkinlikleri süresince katılımcıların kişisel özelliklerine göre değişiklik gösterebilir. Örneğin, etkinlikler devam ederken öncü/lider rolünü farklı bir katılımcının üstlenmesine karar verilebilir.
3. Öğrenme etkinlikleri devam ederken, katılımcılar ihtiyaç duydukları yeni bir rolü ortak olarak tanımlayabilir ve bu yeni rolü kimin üstleneceğine karar verebilirler.

H. Lesson Plan Guide

Teknolojinin Bilişsel Araç Olarak Kullanımına Yönelik

Ders Planı Oluşturma Rehberi

A. Ders Planının Künyesi

Grup adı:

Sınıf seviyesi:

Ünite/Tema adı/Alt öğrenme alanı:

Kazanımlar:

Süre:

Materyaller:

Gerekli ön bilgi:

Öğretim yöntemleri:

B. Ders Planının Uygulamasına Yönelik Detaylar

Öğrenilecek konu:
Bu derste ele alınacak ana konu ve alt konular belirtilir. Bu dersten önceki derslerde ele alınmış ve değinilmemiş olan konular belirtilir ve daha önce ele alınmış konularla nasıl ilişkilendirileceğinden bahsedilir.

Öğrenme çıktıları:
Bu dersin sonunda, belirtilen kazanım/kazanımlar doğrultusunda, öğrencilerden ne beklendiği belirtilir. Öğrencilerden beklentiler hem **konu içeriğini** hem de kullanılan bilişsel araçlarla oluşturulacak **ürünü** kapsayacak şekilde dile getirilir.

Hedef kitle:
Öğrencilerin yaşları, sınıfları, genel özellikleri, bilgi ve becerileri kısaca anlatılır.

Öğrenme ortamı:
Nasıl bir öğrenme ortamında dersin işleneceği belirtilir. Hangi materyallerin ve teknolojik araçların gerekli olduğu, toplam öğrenci sayısı, bireysel çalışmalara ve grup çalışmalarına yönelik detaylar belirtilir.

C. Yapılandırmacı Öğrenme Ortamı Tasarımı İlkelerinin (Jonassen, 1999) Uygulaması

Öğrenme hedeflerine uygun bir problem durumu

Dersteki öğrenme hedefleri doğrultusunda bir problem, proje veya soru belirtilir. İyi yapılandırılmamış bir problem durumu sunulur. İlgili problemin, öğrencileri motive etmesi, öğrenmeye yönlendirmesi ve öğrencilerin kendi öğrenme sorumluluklarını almasını sağlaması beklenir. Problem, ilgili bağlamda (sosyo-kültürel çevre, fiziksel çevre, paydaşlar vb.) paylaşılır. Öğrenci, ders süresince ilgili problemi anlamayı ve çözmeyi hedefler.

İlişkili durumlar

Öğrencilerin problemleri anlamaları ve çözmeleri için benzer durumlar ve çözümlü örnekler paylaşılır. Benzer deneyimler öğrencilere çözüm için yardımcı olur.

İhtiyaç duyulan bilgi kaynakları

Öğrencilerle problemin çözümü için gerekli olan bilgiler ve referans alınabilecek kaynaklar (Basılı materyaller, web siteleri, vb.) paylaşılır. Bu bilgiler ve kaynaklar ışığında, öğrenciler çeşitli varsayımlar kurar ve test eder.

Bilişsel araçlar

Öğrencilerin verilen problemin çözümünde kullanacakları bilişsel araç/araçlar belirtilir. Bu bilişsel araçları, öğrenciler

- konu hakkında bildiklerini göstermek
- problemin sunumunu yapmak
- problemi çözmek için gerekli bilgileri toplamak ve
- problemi çözmek gibi farklı amaçlarla kullanabilir.

Bilişsel aracı/araçları öğrencilerin ne amaçla ve nasıl kullanacaklarına ilişkin detaylar belirtilir. Kullanılan bilişsel araç/araçların öğrenme hedefleriyle nasıl ilişkilendirildiği ve bu bilişsel aracın sağlayacağı katkılar belirtilir.

İletişim ve iş birliği ortamı

Öğrencilerin iş birliği içinde çalışabilecekleri, birbiriyle etkileşime girebilecekleri ve iletişim kurabilecekleri ortamlar sağlanır.

Öğrenme ortamı için sosyal ve bağlamsal destek

Öğrenme ortamı için, fiziksel ve sosyal çevre amaca uygun olarak düzenlenebilir. Öğrencilere, model olma, koçluk yapma ve öğrenme desteği sağlama gibi yöntemlerle destek sağlanabilir. Gerekli durumlarda, öğretmenin ve paydaşların öğrenme ortamı hakkında bilgi edinmesi sağlanabilir.

D. Dersin Akışı

Bir önceki bölümde ayrıntılarını belirlediğiniz, Yapılandırmacı Öğrenme Ortamı Tasarımı İlkeleri (Jonassen, 1999) doğrultusunda dersin akışı oluşturulur. Ders planında,

- Her adımda öğrencilerin ve öğretmenlerin ne yapacağına,
- Bilişsel aracın derse hangi noktada dahil edileceğine ve ders süresince nasıl kullanılacağına,
- Bilişsel aracın öğrencilerin düşünme becerilerine nasıl bir ortak olacağına yer verilir.

Öğrencilerin kullanılan bilişsel araçla ilgili bilgi ve beceri düzeyleri de dersin akışında izlenecek adımlarda göz önüne alınır.

I. Turkish Statements of the English Quotations and Excerpts

Turkish statements of the English quotations are listed here. Bracketed numbers are the identification numbers of the quotations. By following these numbers, corresponding English quotations can be found in text.

[01] "Bir de matematik dersinde biz daha çok işlem yapıyoruz. Soru çözüyoruz. Ekranı paylaşıp, tablet kalemim var. Onlarla birebir göstere göstere gidiyorum. Biraz interaktif olması güzel oluyor, çocukların katılımıyla. Yani daha çok bu şekilde yararlanıyorum." (Interview_01-T01, Konum 11)

[02] "Akıllı tahtayı da genelde z-kitaplarımızla birlikte kullanıyorum. Özellikle ödevlendirme yaptığım kitapların çözümlerinde hem tekrar soruyu yazmakla vakit kaybetmemek hem de onların kendi içinde soruyu yakınlaştıran fonksiyonları oluyor. Üzerine çözümleri yapsanız dahi çocukların sadece o soruyu görebilmesine imkan tanıyan sistemleri çok işimize yarıyordu bizim. Bu anlamda kullanıyordum." (Interview_01-T10, Konum 5)

[03] "Özellikle ders sonu enerjileri düştüğü zaman en azından konuyla alakalı soruları birkaç tane de olsa çözmeleri için yapıyoruz." (Interview_01-T02, Konum 2)

[04] "Konuyu anlattıktan sonra link attık çocuklara, chat bölümünden Zoom'da link attığımızda direkt oyuna yönlendiler." (Interview_01-T16, Konum 4)

[05] "EBA'nın videolarından da yararlanıyorum. Hani konu işledim, mesela atıyorum 6'lar da üslü sayılar işlemiştim. Orada üslü sayılarla ilgili bu satranç tahtası hikayesi var mesela EBA'da, çocuklara onu izlettim. Hani öyle evet ilgisini çekmesi için çocukların EBA'dan yararlanmaya devam ediyorum." (Interview_01-T19, Konum 3)

[06] "Ters yüz sınıfı karantina döneminde daha çok kullanıyorduk. Ders sayısı az olduğu için çocuklar daha çok kendileri çalışıyorlardı. Ama bu sene de kullanacağız. Önümüzdeki haftalarda sınavları başlayacak çocukların. Okullara gelip olacaklar ya sınavları. O zaman ders anlatımı için eve dönecekler. Bir süre alacak bu. Böyle tüm

program kayacak. Orda olan tüm senkron dersleri asenkrona çevirdi okul. Asenkrona çevirdiği için mecburen ters yüz sınıf uygulayacağız. Önceden videoları izleyecekler. Videonun üzerinden konuları geçip, soru çözümüne devam edeceğiz." (Interview_01-T02, Konum 7)

[07] "Vitaminin şeyini çok yararlı buluyorum ben, konuya girişte çok kullanıyoruz onu. Çünkü görselleştirmesi iyi. Çocuk bir tık daha böyle soyut somut arasında, o görsel kısmı en azından görünce daha kolay öğreniyorlar, daha hızlı kavrıyorlar. Milyonları falan anlattığınızda da işte kullandıkları grafikler epey iyiydi." (Interview_01-T02, Konum 5)

[08] "En çok Geogebra… Mesela yeni kullandım, aynı alana sahip farklı dikdörtgenler oluşturma, kenar uzunluklarını değiştirerek. Yani bunu çizerek anlatmak çok mümkün olmuyor. Burada kolaylıkla bir değer girerek, farklı dikdörtgenler elde etmek üzere simülasyonlarından faydalanıyorum." (Interview_01-T01, Konum 6)

[09] "… mesela Morpadaki gibi eğlenceli etkinlikler yaptırdığınız zaman bu onların hoşuna gittiği için öğrenmeleri de biraz daha farklı oluyor. Daha istekli oldukları için daha çabuk öğreniyorlar, diyebilirim. Bu şekilde dikkatlerini daha uzun süre içerikte tutabiliyorlar." (Interview_01-T17, Konum 16)

[10] "O yüzden en önemli şeylerden biri, motivasyon ve çocukların matematiğe karşı olan önyargılarını kırması… Çünkü ilgilerini arttırıyor." (Interview_01-T05, Konum 11)

[11] "Evet çocuğun dikkatini çekiyorsunuz, evet o anda heyecanlı ve dikkatli çocuklarla uğraşıyor oluyorsunuz ama işin esas amacından, benim ders yapma amacımdan kopuyoruz biraz. Kahoot yapıyorsak, o müzikle ilgilenmeye başlıyorlar ve dalıyorlar." (Interview_01-T06, Konum 15)

[12] "Teknolojiyi açıkçası daha çok uygulamalar, konuyu öğrendikten sonra ya da konuyu öğrenmeden önce ön bilgilerini kontrol etmek için kullanıyorum. Ne gibi? Mesela, Kahoot, Quizziz, Quizlet, Scorative gibi araçlar üzerinde daha çok ön bilgileri kontrol edip ona göre bazen dersimi planlıyorum. Dersimiz zaten

matematik, yani daha çok sayısal bir ders olduğu için… Ya da konuyu işledikten sonra küçük bir quiz şeklinde olup, çocuk nerede kalmış, ne yapabilirim, hangisini nasıl yönlendirebilirim, diye geribildirim vermek için kullanıyorum.” (Interview_01-T05, Konum 5)

[13] “Aslında bu ölçme anlamında çok sağlıklı bir uygulama olarak görmüyorum bunu ama yine de çocukların enerjisini arttırmak anlamında iyi bir uygulama olduğunu düşünüyorum.” (Interview_01-T02, Konum 2)

[14] “Aslında eğlendiklerini sanıyorlar fakat bir yandan da öğreniyorlar. Her bir sorunun içinde onlarla konuşuyoruz çünkü. Bakın bu böyle, söylemişsiniz, 3 kişi yanlış cevap vermiş ama aslında nedeni bundan bundan kaynaklı, biz de çaktırmadan soruyu anlatıyoruz onlara.” (Interview_01-T11, Konum 17)

[15] “Ödevleri oradan veriyoruz. Onları oradan yollamasını istiyoruz. Dijital ortamda yapay zekâ ile kimin kaç tane soru yapamadığını, hangi sorunun yüzdesinin ne olduğunu veya hangi soruları daha çok verdik, neleri vermedik gibi bunları da dijital olarak kullanıyoruz platformdan.” (Interview_01-T11, Konum 4)

[16] “Mesela çocuk hangi programa kendini yakın hissediyorsa, hakimse onu kullanarak bir çalışma yapabiliyor. Mesela moviemaker da çocuk ben film yapıyım dedi. Tamam, sıfırın hikayesini işin içine katarak onu film yaparak gönderiyor. Daha çok kendi hazırlayabileceği şeyleri düşünerek, o noktada kullanmalarını da sağlıyoruz derslerde.” (Interview_01-T20, Konum 13)

[17] “Powerpoint sunusu hazırlıyoruz, özellikle video çekimler için hazırlıyoruz. Ama ders anlatımını biz kitabımızdan yapıyoruz. Onu takip ediyoruz. Sadece bazen, mesela sınavlardan önce küçük tekrarlar hazırladığımızda sunular işimize yarıyor. Word’ü soru yazmak için kullanıyoruz tabiki.” (Interview_01-T04, Konum 9)

[18] “Exceli de daha çok sınav sonuçları ile ilgili kullanıyoruz.” (Interview_01-T04, Konum 9)

[19] “Teknoloji zaten çok sevdikleri ve içinde oldukları bir şey. O yüzden onları motive etmekte çok etkisi oluyor.” (Interview_01-T08, Konum 9)

[20] “Padlet’ı ders başında kullanıyorum. Biraz daha çocukları derse odaklamak ve dikkat çekmek amaçlı.” (Interview_01-T20, Konum 11)

[21] “Örneğin, quiz gibi yaptığımda Classkickte her çocuğun ne yaptığını anında görmem çocuk için tespitimi kolaylaştırıyor. İstediğim çocuğa anında tıklayıp o an nasıl yazıyor diye bakabildim. Normal sınıfta bile, sınav kağıdı önüme geliyor ama, o an çocuk nasıl bir düşünceyle yaptı, nasıl yazdı bilemiyorum. Her çocuğun yaptıklarını anlık görebilmek her çocuk için daha iyi not almamı sağladı, çocukları tanıma açısından.” (Interview_01-T05, Konum 11)

[22] “Mesela Hocam soru yazma konusunda, matematikte problemleri yazmak epey zaman alan bir şeydi. Bir derste 5-6 soru çözebiliyorsak tahtaya yazarak, iyi olan gruplar için söylüyorum, bu şekilde 10-15 soru çözebiliyoruz.” (Interview_01-T03, Konum 9)

[23] “Bu şekilde teknolojiyi entegre ederek hem biraz daha anlaşılır hem de biraz daha eğlenceli hale getirebiliriz diye düşünüyorum.” (Interview_01-T17, Konum 24)

[24] “Kendim videoyu da gömüyorum içine, görsellerimi de koyuyorum, sorularımı da koyuyorum. Bu şekilde benim kontrolümde oluyor. Başkasının yazdığı kitap ya da bir text üzerinden bir şeyleri yazdırmaktansa, ben kendim sınıfın potansiyeline göre ya da dinamiğine göre hazırladığım içerikle dersi işlemek hem benim açımdan hem de çocuklarla iletişimim açısından daha faydalı oluyor.” (Interview_01-T06, Konum 11)

[25] “Yani öğrenmeyi öğrenmek. Bu süreçte çocuklara kendi kendine öğrenebilmeyi de öğretmek. Yaşam boyu öğrenmeyi destekleyen bir araç olarak düşünüyorum.” (Interview_01-T24, Konum 16)

[26] “Bir de en önemlisi kendi branşımız adına matematiğe bunu nasıl entegre edebilirim bunu öğrenmeyi amaçlıyorum.” (Interview_01-T10, Konum 14)

[27] “İşin içine kattığımızda, onun dengesini kurarak gittiğimizde faydasını daha fazla görmüş oluruz. Denge için, hepsini bir arada düşünmek gerekiyor.” (Interview_01-T20, Konum 20-21)

[28] “Öğretmen tarafından kullanıldığında ben bir olumsuzluğunu görmüyorum ama çocukların inisiyatifine bıraktığımızda hani tamam yapabilirsin dediğimizde, onlar kötü yönde kullanabiliyorlar. Öğretmen kontrolünde olduğunda ben pek bir zararı olduğunu düşünmüyorum.” (Interview_01-T15, Konum 12)

[29] “Ama tabi matematik dersinde, sözel dersler, sosyal bilgiler, Türkçe gibi çok farklı alanlarda ilerlemek o kadar da geniş olmuyor. Belli bir noktada kalabiliyoruz, diyebilirim.” (Interview_01-T09, Konum 11)

[30] “Bazen öğrenciyi tembelliğe ittiği noktalar oluyor. Mesela atıyorum; kullandığım defterde tıklayınca cevabı açılsın. Hani biraz daha tembelliğe iten noktalar da oluyor. Uğraşmadan hemen görelim. Bu noktada, bazı noktalarda tembelliğe itiyor öğrenciyi. Öğrencinin bir şey yapmasına engel oluyor. Düşünme sürecine engel oluyor çünkü mesela ben oradan bir tıkla cevabı açabileceğim. O yüzden hemen açın cevabı görelim, diğer soruya geçelim. O şekilde tembelliğe iten noktalar olabiliyor.” (Interview_01-T18, Konum 9)

[31] “Öğrenciler için olumsuz etkileri olduğunu düşünüyoruz çünkü henüz gerektiği gibi kullanmayı öğretemedik genel olarak. Sadece okulda değil, dışarda da; öğrencilerden gözlemlediğim bu.” (Interview_01-T07, Konum 6)

[32] “Yani hangi etkinliği yapalımdansa, hangi özelliği dersimizde kullanalım biraz da onu düşünüyoruz.” (Interview_01-T11, Konum 22-23)

[33] “Ancak burada nasıl o entegrasyonu sağlayacağız? Öğretmenin bunu sürekli kullanan konumunda olmasını açıkçası ben istemiyorum. En azından çocuk bir laboratuvara gidebilmeli. Herkes bilgisayar başında bir şeyler yapabilmeli ki ben onun geri dönütlerini, değerlendirmesini ölçme kısmında da görebileyim.” (Interview_01-T22, Konum 20)

[34] “Benim de bilgimi arttırdı. Bu da beni olumlu yönde etkiledi, motive etti mesleki anlamda da.” (Interview_01-T05, Konum 11)

[35] “Çocuklar bir yandan matematiği eğlenerek yapacaklar ama teknolojinin bilişsel olarak da gelişmelerine katkı sunması gerekiyor. Çocuk özellikle kodlamayı

öğrenirken, bir yandan ne yapması gerektiğini düşünürken bir yandan da çözümü düşünmesi gerekiyor olacak aslında. Bu da gerçekten beni heyecanlandıran kısım bu eğitimde." (Interview_01-T14, Konum 17)

[36] "Programı benim çok iyi öğrenmem lazım ki çocuklarda etkisini ben de arttırabileyim. Bunun için biz de deneme süreci içindeyiz ve çok fazla şeye adapte olmaya çalışıyoruz. Ben özellikle şuna dikkat ettim kendimde. Birkaç programı iyi seçip, onlarda kendimi geliştirip çocuklara daha iyi o anlamda ulaşabilmek. Zorluklar şöyle. Çok fazla şey var, doğru aracı seçip doğru şekilde ilerlemek." (Interview_01-T20, Konum 20)

[37] "Çünkü matematiğin sanki onlara entegre olmasını hani çok sağlayabilmiş durumda olduğumu düşünmüyorum açıkçası." (Interview_01-T19, Konum 2)

[38] "Ben o kadar zorlandım ki, bir gün öğlen oturup akşam 6'ya kadar 6 soru yazabildim çünkü onun şeklini çizmem, onu aramam, nerde yapılıyor?" (Interview_01-T23, Konum 13)

[39] "En büyük sıkıntı, online bir şey kullanmaya çalıştığınızda internet bağlantınızın çok iyi olmaması. Sizin ya da çocuğunki kötü olduğu zaman karşılıklı bir iletişim kuramıyorsunuz." (Interview_01-T17, Konum 20)

[40] "Şimdi şöyle bazı çocuklar çok hakim olamıyor, bir üyelik yapması gerekiyor mesela başka bir sistemde. Çocuk çok hakim olamıyor. O konuda çocuğa tek tek anlatmak zorunda kalıyorsunuz. Bu da tabi ders düzenimizde, ders planımızda bir yavaşlamaya da sebep oluyor." (Interview_01-T04, Konum 17)

[41] "Kazanımı matematik olarak ben biliyorum ama bağdaştırma noktasında bilişim öğretmeni ile birlikte gitmediği zaman bir yerde kalıyorum. Ama öğretmen farklı bir fikir veriyor. Orada daha güzel bir şeye dönüşmüş oluyor uygulama." (Interview_01-T20, Konum 23)

[42] "Ben zaten oturmaya alışkın değilim, normalde 2 dk falan oturuyoruz. Şimdi böyle oturarak ders anlatmak böyle çok daha yorucu. Bire bir buçuk bence." (Interview_01-T02, Konum 9)

[43] “Ders içinde biz zoomda bile, hiçbir teknolojik araç kullanmasak bile, arkada bir oyun açtınız mı, derse adapte olun, kamerayı açın gibi sorunlarla baş ediyoruz.” (Interview_01-T10, Konum 10)

[44] “Online eğitim olunca, matematik dersine olan motivasyonları düşüyor, ilgileri düşüyor, sıkılabiliyorlar.” (Interview_01-T05, Konum 5)

[45] “Yani ben öğrencinin gözlerine bakarak, sınıf ortamında gerçekten bir şey anlayıp anlamadığını görmek daha kolay.” (Interview_01-T24, Konum 8)

[46] “Biz işte hani Kahoot’u duyuyoruz kendimiz araştırıyoruz, Zoom’u öğrendik mecbur kaldık.” (Interview_01-T23, Konum 13)

[47] “Çünkü uzaktan eğitimde çok zor oluyor matematiği anlatmak, canlı da bile zorlandıkları bir ders, uzaktan daha da zor.” (Interview_01-T15, Konum 10)

[48] “Ders planlarını yaparken, tabiki teknolojiyi işin içerisine katıyoruz ama bu ön hazırlık demek. Yaptığımız ön hazırlığın biraz daha kapsamlı halini gerektiriyor ve bu sefer şey oluyor. Bir tane yapıyoruz, bu iyiydi ama şöyle olsaydı daha iyi olurdu. Her defasında kendimizi geliştirerek, daha çok zaman ayırmak gerekiyor. Biraz daha kendimizden zaman alıp, teknolojiyle uğraşıyoruz.” (Interview_01-T14, Konum 15)

[49] “Sadece ders saatim uygunsa, beni geride bırakmıyorsa müfredatımdan, ne kadar çok kullanabiliyorsak bence o kadar iyi diye düşünüyorum.” (Interview_01-T11, Konum 19)

[50] “Merak duyuyordum ama mesafeli kaldım. Neden; zamansızlıktan ötürü. Biraz branşımız gereği ders saatlerimiz çok yoğun, kendinize ayıracağınız çok zamanınız kalmıyor açıkçası. Dolayısı ile çok kendimi geliştiremedim ama ilgi duydum.” (Interview_01-T16, Konum 19)

[51] “En çok başka şeylere dikkatleri kayıyor ve o an dersin içeriğinden kopmuş oluyorlar. Benim göstermek istediğimden kopuyorlar.” (Interview_01-T17, Konum 18)

[52] “Doğrusunu göstermek ya da yanlışını düzeltmek noktasında dikkatleri tekrar toplamakta zorlanıyorum kendi adıma.” (Interview_01-T06, Konum 15)

[53] “Olumsuz kendi dersim adına işlem basamaklarını göremeyişim. Sadece sonucu görebiliyorum ben.” (Interview_01-T08, Konum 11)

[54] “Bir de matematik dersinde biz daha çok işlem yapıyoruz. Soru çözüyoruz.” (Interview_01-T01, Konum 11)

[55] “O gelenekselci yaklaşım zaten büyük oranda kırılmıştı ama şu anda yok diyebiliriz.” (Interview_01-T24, Konum 2)

[56] “Çok değişik programlar var, tabii biz bilmiyoruz. Üniversitede okurken de hiç göstermediler. Ben bir de bölüm mezunuyum, matematik bölümü. Formasyon aldım ama formasyon çok hızlı bir şekilde verildi. Eğitimi daha farklı şekilde anlatabilirsiniz, klasik yöntemden sıyrılın, şu şekilde öğrenciye matematiği sevdirin hiç bunları bu şekilde görmedik biz.” (Interview_01-T15, Konum 16)

[57] “Matematik dersinde çok fazla teknoloji ben şahsen kullandığımı düşünmüyorum.” (Interview_01-T16, Konum 8)

[58] “Ders planı Yapılandırmacı Öğrenme Ortamı Tasarımı Modeli ilkelerine uygun şekilde bu ilkelerden yararlanarak hazırlanmış. Öğrencilere tam olarak yapılandırılmamış bir problem bağlamı oluşturulup günlük yaşantılarıyla bağlantılı olarak problem durumu sunuluyor. Öğretmenin kılavuz olarak kaldığı bu planda öğrenciler örnek durumları inceleyerek bilgi kaynakları ve bilişsel aracı kullanıp probleme çözüm üreterek kazanımı kavrıyor.” (Grup03-Discussion_Activities, Konum 5)

[59] “T02 öğretmenimin dediği gibi bilişim teknolojileri öğretmeni tarafından öğrenciler ile ön hazırlık yapmasını isterdim.” (Grup02-Discussion_Activities, Konum 38)

[60] “Tablo ve grafikleri Excel yardımıyla oluşturmak, aritmetik ortalama ve açıklığı hesaplatmak yada cebirsel ifadelerde bilinmeyen yerine bir tam sayı yazıp, ifadenin

değerini hesaplatmak onlar için güdüleyici bir çalışma olacaktır.” (Grup04-Discussion_Activities, Konum 15)

[61] “T28 Hoca ve T10 Hoca da problem durumlarını öğrencilerin kendileri için önemli gördükleri ve ilgilerini çeken durumlarla güncelleyebileceğini belirtmiş. Örnek durumlar, uygulanan öğrenci grubunun bağlamı ve ilgi alanları düşünülerek değiştirilebilir diye düşünüyorum. Siz ne dersiniz?” (Grup03-Discussion_Activities, Konum 31)

[62] “Öğrenciye gösterilen çeşitli hız-zaman grafiklerinin bazı öğrencilerin dikkatini çekebileceği gibi bazı öğrencilerin de gözlerini korkutabileceğini düşünüyorum.” (Grup01-Discussion_Activities, Konum 7)

[63] “3 ders saatinden daha uzun bir sürece yayardım ki konu ve etkinlikler için yeterli özümseme süresi olsun. Etkinliklerden sonra öğrencilerin öğrendiklerini sentezleyip grup çalışmasıyla konuyla ilgili kendi etkinliklerini oluşturmalarını isterdim. Grup olarak sunulan etkinlikleri diğer gruplara rubrik üzerinden değerlendirtirdim.” (Grup02-Discussion_Activities, Konum 19)

[64] “Ders planını hazırlarken belki süre daha uzun tutulabilirdi. Bireysel çalışma süresi ortalama düzeydeki bir 8.sınıf öğrencisi için yeterli olur mu?” (Grup03-Discussion_Activities, Konum 23)

[65] “Örneğin çocuklar mobil oyunlar ve oyun parklarındaki makine oyunları ile ilgililer. Bu oyunlarla oynarken puan toplamak onlar için önemli. Etkinlik konusu olarak oyun abonelikleri ya da oyun parklarındaki makinelerde kullanmak üzere bir abonelik sorusu tasarlamanın onların güdülenmesinde daha etkili olacağı düşüncesindeyim. Verilen örnekler günlük yaşamla direk bağlantılı olsalar da öğrencilerin ilgisini çekecek kadar onların dünyalarına ait değiller.” (Grup04-Discussion_Activities, Konum 11)

[66] “Yorum yazan tüm öğretmenlerimizin yorumlarını incelediğimde aslında genel olarak fikir birliğinde olduğumuzu görüyorum. Grubun raporlama görevi üstlendiğim için okuduklarımın kısa bir özetini ifade etmek isterim. Yorum yapan öğretmenler olarak hepimiz ortaya konan problemin Jonassen'ın Yapılandırmacı

Öğrenme Ortamı modelinde yer alan ilkeler doğrultusunda hazırlanmış ,öğrenciyi motive eden öğrenmeye güdüleyen bir plan ile öğrencilere sunulduğunu fakat bu plan doğrultusunda yer yer öğrencilerin sıkılabileceğini veya Excel bilgisi dolayısıyla eksik kalabileceklerini, sürenin de verimli kullanılamayacağını düşünüyoruz. Ders planını kendimiz oluşturduğumuzda süreyi uzatıp, kullanılan programı değiştirebileceğimiz yönünde fikir birliğimiz var." (Grup01-Discussion_Activities, Konum 28)

[67] "Tasarladıkları oyun sayesinde özellikle değişken kavramını anlamlandırmalarında faydalı olduğu gözlemlendi. Grup çalışması ile öğrencilerin birbirleriyle fikirlerini paylaşması da akran öğrenmesini pekiştiren önemli bir unsur oldu." (Grup01-Discussion_Activities, Konum 130-131)

[68] "Ben de T17 öğretmenime katılıyorum . En çok zorlandıkları kısım tahmin etme becerisini kodlamaya dökme olduğu fikrine katılıyorum." (Grup04-Discussion_Activities, Konum 169)

[69] "Farklı formüllerle sonucu bulan öğrencilerin fikirlerini paylaşması da akran öğrenmesini pekiştiren önemli bir unsur oldu." (Grup01-Discussion_Activities, Konum 39)

[70] "Diğer öğretmen arkadaşlarımızın da paylaşımında olduğu gibi Scratch uygulamasının bütün öğrencilerin hakim olması, program yazma becerilerini tamamlamış olması gerekmektedir." (Grup02-Discussion_Activities, Konum 67)

[71] "İki ders saati yeterli olmadığından ders süresini arttırır ve örnekleri çeşitlendirirdim." (Grup04-Discussion_Activities, Konum 157)

[72] "T18 hocam iyi akşamlar. Bizim de uygulama yaparken eksik gördüğümüz kısımdan mı bahsettiniz tam anlayamadım. Gereken kodu ilave ettiğiniz halde mi sıkıntı yaşandı?" (Grup03-Discussion_Activities, Konum 195)

[73] "Ders planının uygulanmasının 2 ders saatinden daha fazla zaman gerektirdiği gözlemlendi.Ders saati arttırılabilir ve öğrencilere düşünmeleri için daha çok zaman verilebilir." (Grup04-Discussion_Activities, Konum 170)

[74] “Ortak bölen ve ortak kat öğrencilerin zorlandıkları ve kavramalarının zor olduğu bir konu olduğu için bilişim teknolojileri ile iç içe geçmesi öğrencilerin ilgisini çekecek ve öğrenmeyi kolaylaştıracaktır diye düşünüyorum.” (Groups-Main_Discussion, Konum 38)

[75] “Bu planı ben de bu şekilde uygulardım.” (Groups-Main_Discussion, Konum 103)

[76] “Öğrencilerin tekrarlı toplama ile tekrarlı çarpma arasındaki farkı daha iyi gözlemleyebilirler. ayrıca grafiğe dökülmesi gelecek yıllara da yönelik bir hazırlık olabilir.” (Groups-Main_Discussion, Konum 73)

[77] “Matematiğin günlük hayatta keyifli kullanıma uygun ve keşfedici bir plan olmuş ,ben bu planı bu olduğu haliyle uygulardım. Paylaşımlardan çıkardığım sonuç zaman kullanımı ile ilgili sorun yaşamamak adına zamanı etkili kullanabileceğim bir süre seçerdim.” (Groups-Main_Discussion, Konum 157)

[78] “Aynı dersi ben planlıyor olsaydım exceli daha aktif kullanılmalarını sağlayacak (formül vb.) bir çalışma eklerdim.” (Groups-Main_Discussion, Konum 49)

[79] “Excel ders planımızı sınıfta uygularken, bir öğrencimiz dedi ki: Ya öğretmenim bu formülü kısaltabiliriz. Bunu ben hiç söylemedim onlara.” (Interview_02-T05, Konum 17)

[80] “Belirtilen kazanımlara uygun olarak, öğrenciler bir illüzyonistin gösterisinde yararlandığı cebirsel ifadeyi keşfederler. Ardından, illüzyonistin sırrını oluşturan cebirsel ifadeyi gösterisinde nasıl kullandığını gösteren bir oyun tasarlarlar ve ilgili oyunu test ederler.” (Grup1_Ders_Planı_Scratch, Konum 17)

[81] “Öğrencilerin ilgili etkinlikler aracılığıyla ele aldıkları problemler sonrasında, değerlendirme bölümünde benzer çözüm yollarını uygulayabilecekleri farklı örnekler ele alınır.” (Grup1_Ders_Planı_Excel, Konum 21)

[82] “Öğrencilerle problemin çözümü için gerekli olan bilgiler ve referans alınabilecek kaynaklar paylaşılır. (Problem durumuna ilişkin detayların yer aldığı

etkinlik dosyası, Excel kullanımı hakkında bir hatırlatma dosyası, vb.) Bu bilgiler ve kaynaklar ışığında, öğrenciler çeşitli varsayımlar kurar ve test eder.” (Grup4_Ders_Planı_Excel, Konum 9)

[83] “Bu ders planının sonunda öğrencinin Scratch’te ondalık sayıları çözümleme becerilerini de kullanarak bir programlama yapması beklenmektedir. Bu üründe, öğrenci hem bildiklerini kullanarak bir ürün yaratacak hem de bu üründe çeşitli denemeler yaparak genellemeye gidebilecektir.” (Grup2_Ders_Planı_Scratch, Konum 14)

[84] “Bu dersin sonunda, "M.6.1.2.5. İki doğal sayının ortak bölenleri ve ortak katlarını belirler." kazanımı doğrultusunda, öğrencilerin farklı doğal sayılar arasındaki ortak kat ilişkisini kurması beklenir. Bu ilişkiyi kurarken, sayıların kendi katlarını belirlemesi, bu katları Excele girmesi ve Excel yardımıyla bir tablo oluşturarak, iki ya da üç doğal sayının ortak katlarını belirlemesi beklenir.” (Grup3_Ders_Planı_Excel, Konum 6),

[85] “Bu doğrultuda, Arda ve Özge ilk hafta ellerinde iki meyve sineği olduğunda, beş hafta sonra kaç meyve sineği olacağını tahmin etmek istemişlerdir. Birinci haftadan başlayarak ilk 5 haftayı sırasıyla Arda, 2, 4, 6, 8 ve 10 olarak düşünmüş; Özge ise, 2, 4, 8, 16, 32 olarak düşünmüştür.

a) Bu doğrultuda, Excel ile haftalara göre Arda ve Özge’nin meyve sineği nüfusu tahminlerini tablo ile oluşturunuz.

b) Hangisini doğru düşünmektedir? Bir diğer deyişle, hangi tablo meyve sineği nüfusunun her hafta iki katına çıktığını göstermektedir?

c) Doğru olmayan tablo neyi ifade eder?

d) a’yı hafta sayısı olarak belirterek, “2a”, “2 üzeri a” ve “a üzeri 2” değerlerini gösteren bir tablo oluşturunuz.

e) Hangi ifade Arda'nın tablosunu ifade ediyor? Hangi ifade Özge'nin tablosunu ifade ediyor?

f) a yerine 0'dan 5'e kadar değerler verdiğimizde, hangi ifade değerleri en hızlı arttırıyor?

g) d şıkkında oluşturduğunuz tablodaki üç ifadenin haftalara göre grafiklerini oluşturunuz ve f şıkkındaki yanıtlarınızla grafikleri ilişkilendiriniz." (Grup4_Ders_Planı_Excel, Konum 11)

[86] "Bu dersin sonunda, öğrencilerin kesirlerle yapılan bir problem durumunda, kesirleri, çeyrek, üçte bir, yarım gibi kesirlerle ilişkilendirerek tahminlerde bulunabilmesi beklenmektedir. Bu doğrultuda, dersin sonunda Scratch'te bir oyun tasarlayacaklardır. Oyunda, 0 ile 1 arasında verilen bir kesrin sayı doğrusunda 0 ile çeyrek, çeyrek ile üçte bir ve üçte bir ile yarım gibi aralıklardan hangisinde olduğunu tahmin etmeleri istenmektedir. Bu tahmin sonrasında, kesrin hangi kesre daha yakın olduğuna karar vermeleri istenmektedir. Öğrencilerin tahmin becerilerini gözlemleyerek geliştirebilecekleri bir oyun üretmeleri sağlanacaktır." (Grup4_Ders_Planı_Scratch, Konum 9-10)

[87] "Öğrencilerin iş birliği içinde çalışabilecekleri, birbiriyle etkileşime girebilecekleri ve iletişim kurabilecekleri bir uzaktan eğitim ortamında ders planlanmaktadır (Pandemi nedeniyle). Öğrencilerin ikili grup çalışmaları bulunmaktadır." (Grup3_Ders_Planı_Excel, Konum 8)

[88] "Bu ders, online ortamda gerçekleşeceği için her öğrenci kendi bilgisayarı ile zoom programı üzerinden ders katılır. Scratch'e tarayıcı üzerinden erişilebilir ve her öğrencinin hesabının önceden oluşturması ve bu hesap üzerinden proje dosyasını paylaşması istenir. Derse bağlandıktan sonra ise etkinlik kağıdı ekranda paylaşılmalıdır. Desteğe ihtiyaç duyan öğrencilere BT ve Matematik öğretmeni tarafından gerekli destek sağlanır. (Grup2_Ders_Planı_Scratch, Konum 15-16-20)

[89] "Ana gruba dönüldükten sonra, Etkinlik-1'in üzerinden topluca geçilir. Ardından aynı şekilde gruplara dönülerek, Etkinlik-2 üzerinde çalışacakları belirtilir." (Grup2_Ders_Planı_Excel, Konum 17)

[90] “Öğrencilerin excel programında yazmak istedikleri kurallar için yeterli düşünme zamanı verilir ve ekranlarını paylaşmaları istenerek interaktif olarak onlara gerekli yönlendirmeler yapılır.” (Grup1_Ders_Planı_Excel, Konum 60)

[91] “Ders sırasında hem matematik öğretmeni hem BT öğretmeni grupların çalışmalarını kontrol eder, rehberlik eder ve ihtiyaç duyan öğrencilere destek sağlar.” (Grup3_Ders_Planı_Excel, Konum 14)

[92] “Grup arkadaşınız ile bir sayı belirleyin ve yazdığınız programı test edin. Belirlediğiniz sayı nedir? Belirlediğiniz sayıyı 10, 100 ve 1000 ile çarptığınızda ne gözlemlediniz? Bir ondalık sayıyı 10 ile çarptığınızda nasıl bir genelleme yapılabilir?” (Grup2_Ders_Planı_Scratch, Konum 47-64)

[93] “Çünkü onlar bizden çok daha fazla ilgililer, meraklılar ve daha iyi yapabiliyorlar.” (Interview_02-T14, Konum 6)

[94] “Olumlu yanları, bir kere farklı bir şey yapmak onların ilgisini çekti.” (Interview_02-T04, Konum 18)

[95] “Çünkü kendimiz sözel olarak bahsettiğimiz durumlarda öğrencinin dikkatini tam olarak çekemeyebiliyoruz ama etkili bir ders planı hazırlayıp böyle bir aracı dersin içerisine soktuğumuz zaman kesinlikle öğrencilerde daha fazla merak uyandırıyor. Bunu zaten uygulamalarımızda görmüş olduk.” (Interview_02-T03, Konum 8)

[96] “Yani açıkçası akademik olarak o kazanımda zorlanan öğrencilerimiz de vardı ama onların da dersle daha çok ilgilendiğini fark ettik.” (Interview_02-T07, Konum 6)

[97] “Genel olarak değil ama birkaç öğrencide şunu gözlemledim. Excelde ve Scratch’te, ve hatta özellikle Scratch’te zorlandıkları için, o anlık ders içinde motivasyonlarının düştüğünü gözlemledim.” (Interview_02-T05, Konum 21)

[98] “Bilişsel bir araç olarak, yani onların kullanacağı bir teknoloji daha da etkili oluyor. Öğrenci, genelde öğretmenin gösterdiği ve yaptırdığı adımlara alışık. Bu

planlarda, öğrenci hep kendi teknolojiyi kullandı, kendi denedi, çözüm üretti." (Interview_02-T02, Konum 12)

[99] "Bunu kendileri yaptıkları için de daha çok seviyorlar ve daha çok akıllarında kalıyor." (Interview_02-T17, Konum 12)

[100] "Çocuğun çok daha iyi kavradığı, anladığı noktalar oluyor teknolojiyle birlikte." (Interview_02-T16, Konum 8)

[101] "Excel'de de aynı şey oldu. Alan hesabında da hemen işte aa çarpımları hepsinin 48 olacak falan. Excel'de işte böyle karşılarında bir tablo olunca, görsel olarak da alınca çok daha çabuk çözebiliyorlar yani." (Interview_02-T08, Konum 13)

[102] "Hani böyle daha basit konularla ilişkilendirmek isteseydik, belki de hazırlık süreci için harcadığımız bu emek boşa gidecekti. Öğrencinin anlamakta zorlandığı, daha karmaşık bir konuda bilişsel bir araçtan destek almak çok önemli." (Interview_02-T19, Konum 29)

[103] "Öğrencinin içinde olduğu, fikir beyan ettiği, dersin işleyişine katkı sunduğu, öğrencinin kendi yaptıkça ilerlediği bir ders olması tabiki etkililiğini arttırıyor." (Interview_02-T06, Konum 20)

[104] "Yani bundan sonra da herhangi bir teknolojik araç kullansam da kullanmasam da ders planı örneklerini, bundan sonra ders planı hazırlama aşamasında kullanacağımı, planlarımı daha aktif hale getireceğimi düşünüyorum." (Interview_02-T07, Konum 46)

[105] "Hep sorarlar bize. Bu ne işimize yarayacak, bu ne işimize yarayacak? Ama burada günlük hayatın içinden problemleri çözerken matematikten ve ilgili teknolojik araçtan yararlandılar. Günlük hayatın içinde olduğunu gördüler." (Interview_02-T12, Konum 17)

[106] "Onlar için de yeni bir ufuk açtığını düşünüyorum. Matematiğin kullanım alanlarıyla ilgili, teknolojiyle matematiği nasıl birleştirebiliriz ile ilgili." (Interview_02-T01, Konum 13)

[107] “Teknolojiyle iç içe olduğumuz bu dönemde teknolojik araçları derste daha aktif kullanmanın, öğrencilerin teknolojiyi doğru şekilde kullanması için yol gösterici olacağını düşünüyorum.” (Interview_02-T02, Konum 24)

[108] “Bir hatırlatma gerekti. Bir de matematikle ilişkilendirmek onları zorladı. Nasıl yapacağım, ne yapacağım? Burada neyi kullanacağım? Bu derse kadar böyle bir şeyle karşılaşmadılar. Belki bu kısımlar, müfredatta ilgili yerlere eklenebilir. Ya da buna yönelik ilkokuldan itibaren çalışmalar yapılabilir, bu tarz etkinlikler mesela.” (Interview_02-T22, Konum 11)

[109] “O nedenle öğrenime gerçekten büyük katkı sağladı diyebilirim. Çünkü biri bir şey yaptı, diğeri onun içine katkı yaptı. Çok iyi bir ortam oluştu.Tam bir takım çalışması halinde ürettiler projelerini yani.” (Interview_02-T14, Konum 13)

[110] “Uygulamada bu grupların nasıl oluşturulduğuna da dikkat etmek gerekir diye gördüm.” (Interview_02-T05, Konum 30)

[111] “Bu şekilde teknolojiyi kullanmalarının düşünce becerilerini geliştirmede ve ilişkilendirmede büyük olumlu katkıları olacağını düşünüyorum.” (Interview_02-T10, Konum 20)

[112] “Hani aslında çok iyi anlayamamış veya 2 dakikada çözemeyeceği; excelin kolaylığını ya da Scratch in hem eğlencesini katabileceği hem de öğrencinin kodlarken matematiksel ilişkiyi daha kolay görebileceği bir kurgu yaparım. Bu çocuk “Kalem kağıtla bunu zaten yaparım. Niye uğraşayım?” diyor. Bu eleştiriyi almayacağım bir konu seçmek isterim.” (Interview_02-T12, Konum 24)

[113] “Uzun vadede merak ettiği şeyleri kendi araştırarak öğrenen bireyler yetişiyor.” (Interview_02-T02, Konum 15)

[114] “Matematik dersinde müfredatta bir konuya uzun bir zaman ayrılıyor. O uzun konunun en azından bir iki saatinde mutlaka böyle bir bilişsel araç kullanımına yer vermeliyim, diye düşünüyorum.” (Interview_02-T19, Konum 24)

[115] “Uygulamaya yönelik de dediğim gibi, öncelikle zamanı dikkate alırım. Çünkü 40 dakika planladığımız dersin iki derste çok daha iyi uygulanabileceğini gördüm.

Daha geniş bir zamana yayarak uygulamak, çok daha etkili olacaktır." (Interview_02-T06, Konum 32)

[116] "Bu bizim bu tür bir ders planına ne kadar zaman ayrılması gerektiğini kestirememiş olmamızdan da kaynaklandı." (Interview_02-T14, Konum 15)

[117] "Yani ben senenin başında genel olarak o konu bütününde nasıl bir çalışma yapacağıma karar vermiş olmalıyım. Böylece zaman kullanımım da daha farklı olur. Bu tür bir etkinliğe sonradan yer vermek zor açıkçası. Çünkü öğrencilerin o bilişsel aracı da hatırlaması, öğrenmesi gerekiyor." (Interview_02-T14, Konum 23)

[118] "Bir de bunun birçok kez uygulanması. Evet biz bu sene uyguladık ama gelecek sene yine 6'lar 7 olacak, 7'lere farklı bir şey uygulayabiliriz ki ortaya gerçekten somut bir şeyler çıksın. Çocuklar da bu yöntemle bir şeyler yapmaya çalışsın." (Interview_02-T18, Konum 20)

[119] "Hangi kazanımda öğrencinin anlamasını kolaylaştıracak, öğrendiğini kendi uygulayabileceği bir bilişsel araçtan yararlanabiliriz. O araçları bizim de düşünmemiz gerekiyor. Tabii her kazanımı da uygulamak mümkün olmayabilir ama uygun olan kazanımları tespit edip uygulamayı isterim açıkçası." (Interview_02-T09, Konum 9)

[120] "Bir de öğrenciye daha kolay rehberlik edebilmek için yüz yüze ortamda bilgisayar labında uygulamak daha güzel olurdu." (Interview_02-T11, Konum 4)

[121] "Örneğin biz Scratch planını okulda yüz yüze uygulama şansına sahip olduk. O yüz yüze de geri dönüşleri hemen görüp, o bizi daha çok etkiledi." (Interview_02-T07, Konum 6) (Interview_02-T07, Konum 6)

[122] "Diğer arkadaşlarımızın hazırladığı planlardaki farklı örnekleri görmek de çok yararlı oldu. Önümüzdeki yıl planlama sürecinde, onların etkili bulduğu örnekleri de kendi sınıflarıma taşımayı düşünüyorum." (Interview_02-T02, Konum 22)

[123] "Her yeni aracı gördükçe, bence bakış açımız genişler. Kıyaslamalarımız artar." (Interview_02-T21, Konum 48)

[124] “Bilişim teknolojileri öğretmeniyle bizim de planlamalar yapmamız gerekiyor. Örneğin, Scratch’i öğretirken, bir taşta iki kuş vurmak gibi, hemen matematik dersinde de kullanabileceğimiz bir konuda Scratch’i bilişsel araç olarak kullanabiliriz.” (Interview_02-T09, Konum 60)

[125] “Hepsini kendi zümremle de paylaşıp, önümüzdeki dönemde yararlanmayı düşünüyorum.” (Interview_02-T11, Konum 16)

[126] “Şu anda zümrede tek benim bu eğitime katılarak, bu eğitimi almış olmam okuldaki uygulamalar açısından yaygınlaştırmak için oldukça zor. Bu benim açımdan olumsuz bir yön. Belki daha küçük zümrelerde, zümre arkadaşlarıyla paylaşıp yaygınlaştırmak daha kolay olur.” (Interview_02-T22, Konum 9)

[127] “Aslında belki 6'lara uyguladık ya, belki de bütün kademelere yapılsaydı daha mı farklı olurdu? Daha mı çok çalışma çıkardı bizim için de? Biz evet 6. Sınıfın farklı kazanımlarını seçtik ama belki 5, 6, 7 olarak çeşitlendirilebilir. Hani kademe olarak. Belki lise gruplarında da nasıl bir şeyler çıkacak bakılabilirdi?” (Interview_02-T03, Konum 54)

[128] “Bunu disiplinler arası yaymak gerektiğini düşünüyorum. O yüzden de bunun okul geneline entegre edilmesi gerektiğini düşünüyorum. Bilişim dersinin aslında sosyal bilgilere, Türkçeye bile uyarlanması gerektiğini düşünüyorum.” (Interview_02-T09, Konum 33)

[129] “Gerçi şöyle de bir şey var, siz zaten etkinliği öğrendikten sonra onu farklı kazanımlara uygulamaya adapte edebilirsiniz. Benim şimdi mesela hep aklımda 5. Sınıflara da giriyorum ama bunu orada da kullanabilirim dediğim bir sürü şey oluyor.” (Interview_02-T08, Konum 53)

[130] “Ama daha çok konuyu öğretirken kullandığımız sorulara örnek sorular değerlendirme kısmında yer alıyordu. Belki de benim tarzıma uygun olmadığı için. O anda öğrendiniz mi tamam, mesela dersin sonuna geldik bir tane ürün verebilirdik. Ödevlendirme yapıp, o ödevi değerlendirebilirdik. Değerlendirme kısmını ben daha geniş tutmak isterdim her iki örnek ders planında da.” (Interview_02-T06, Konum 37)

[131] "Bir kere çocukların hazır bulunuşluğu, mesela bizim bu kadar kolaylıkla uygulamamızın sebebi çocuğun ön bilgisinin sağlam olmasıydı. Bu hem matematik bilgisi olarak hem de program bilgisi olarak. Mesela hiç Scratch bilmeyen çocuğa uygulatmak çok daha zor olurdu." (Interview_02-T18, Konum 20)

[131] "Zaten o nedenle biz seneye ilk yapacağımız şey olarak öğrencilerin bu düzeylerini daha yoğun bir hatırlatma süreciyle başlatmak olarak belirledik. Bunu yine planlamıştık bu sene de ama online ortamda olmaları olumsuz etkiledi. Bizde bu sene 5 ve 6'lara BT dersi yoktu mesela… O yüzden onlar için biraz daha kötü bir döneme denk geldi." (Interview_02-T05, Konum 21)

[132] "Scratch'te mesela ön bilgi verdik, işte değişken nedir mesela, bizim ekiple yaptığımızda, katsayı nedir, dört işlem hatırlattık, işlem önceliği hatırlattık. Tabii ki ön bilgi olması gerekiyor. Anlayabilmesi ya da yorum yapabilmesi ya da ekip çalışmasında kendisinin de bir parça olarak hissedebilmesi için tabii ki ön bilgi olması şart bence." (Interview_02-T16, Konum 20)

[133] "Online ortamda bile, biz odaları BT öğretmeniyle birlikte ayrı odalara dağılarak destek sağladık öğrencilere. Matematik öğretmeni olarak, ben oradaki matematiksel ilişkiyi kurmaları için destek sağladım daha çok. Ne yapıyoruz, ne için yapıyoruz?" (Interview_02-T22, Konum 49)

[134] "Belli bir yere kadar mesela çocuk ben anlamadım, bilmiyorum scratch'i diyor. Ama yanında olsaydık biligisayar ortamında, ben ona göstererek anlatırdım." (Interview_02-T15, Konum 58)

[135] "Yani siz öğretmen olarak öyle bir etkinlik planı hazırlıyorsunuz ki, öğrenciye o problemi verdikten sonra sadece rehberlik ediyorsunuz. Bu bence hep hedeflenen bir şey… Öğrencinin aktif olması… Dolayısıyla bilişsel araç olarak kullanım bunu bize örneklemiş oldu." (Interview_02-T20, Konum 8)

[136] "Yani olumsuz yanı da biraz daha toplamam zor oluyor sınıfı. Çocuk kalem kâğıt olmayınca sanki biz oyun oynuyormuşuz modunda yaklaşıyordu. Biraz daha derse toparlamam zor oldu. Yüz yüzede de aynı durum söz konusu." (Interview_02-T18, Konum 8)

[137] “Gerçekten yukarıdaki başarılı öğrenciyi süreçte tutabildik. Akademik olarak başarısız öğrenci de orada bir etkinlik var, bir şey var diyerek ve bu çocuklar z kuşağı, yani teknolojik araçlara bizlerden belki çok çok daha yatkın ve onların da ilgileri arttı. Yani iki uç sınırdaki öğrenciyi de yakalayabildiğimi hissettim bu uygulamalarda ve çok mutlu oldum gerçekten. En üst seviyedeki öğrencim de alt seviyedeki öğrencim de süreç boyunca hep aktifti.” (Interview_02-T03, Konum 14)

[138] “Yani şöyle matematik dersinin içine bilgisayarla alakalı bir program girdiği zaman sanki oyun oynuyormuş… Sanki böyle geçici bir şey, önemli bir şey yapmıyormuş gibi düşünüyorlar yani. Çünkü daha tam sürekli kullanmadıkları için, onu normal dersin parçası olarak görmedikleri için, o hissiyat vardı çocuklarda.” (Interview_02-T18, Konum 8)

[139] “Kodlama konusuna ilgi duymayan öğrenci için hem kodlamayı anlamaya çalışmak hem de mathematisel ilişkilendirmeyi görmek çok daha zor.” (Interview_02-T02, Konum 13)

[140] “Evet, biz bu bilgisayarla bir şeyler üretebilirizi onlara veriyor oluşumuz, disiplinler arası eğitimin bir arada gidiyor oluşu ve bu matematik bazında konuştuğumda ön yargılarını kırıyor oluşu. Matematik korkutucu ve sıkıcı bir ders değildir. Çünkü eğlence katılabilir. Günlük hayat ile ilişkilendirilebilir.” (Interview_02-T10, Konum 19)

[141] “Biraz kaçırmış olabilirim çünkü birden fazla şeye konsantre olunca dağılabiliyorum bazen. Orada bazen sıkıntı oldu onun dışında takip etmeye çalıştım, katılmaya da çalıştım her verdiğiniz etkinlikte.Ama tabii kaçırdığım şeyler olmuş mudur ondan emin değilim. Daha iyi konsantre olabilsek, çok daha iyi olurdu.” (Interview_02-T04, Konum 38)

[142] “Okul süreci, pandeminin getirdiği değişiklikler, müfredatı yetiştirme kaygısı gibi şeyler bizi belki programı iyi takip edemememize neden olmuş olabilir. Bu durum beni engelledi bazı noktalarda. O baskıyı üzerimde hissettiğimde, önceliği maalesef istemesem de diğer işlere verdim.” (Interview_02-T19, Konum 55)

[143] “Ama onun dışında bence diğer aldığım eğitimlerden, durup bir seminer dinlemekten, birinin yaptıklarını izlemekten çok daha fazla katkısı oldu. Çünkü birebir.” (Interview_02-T10, Konum 59)

[144] “Çok iyi derecede değil açıkçası. Bu konuda ben kendimi eleştirebilirim. Biraz daha aktif katılabilirdim.” (Interview_02-T07, Konum 42)

[145] “Ama benim bu konuda bir merağım olduğu için, hep dahil oldum.” (Interview_02-T14, Konum 49)

[146] “Yani bizim de motivasyonumuz sürecin belirsizliği sebebiyle zaman zaman inişli çıkışlı oldu. Hep öğrencileri konuşuyoruz ama ben de diyorum biz öğretmenler ne olacağız?” (Interview_02-T01, Konum 58)

[147] “Bu çalışmayla ilgili kendi motivasyonları etkilemiş olabilir. Gerçekten konu ilgisini çekenler biraz daha detaylı paylaşımlarda bulunuyordu.” (Interview_02-T22, Konum 43)

[148] “Dolayısıyla onların bu heyecanını derste paylaşabilmek için öğretmen olarak biz de daha çok motive oluyoruz böyle teknolojiyi öğreneceğimiz eğitimlerde.” (Interview_02-T18, Konum 48)

[149] “Bir de okul yönetimlerinin de bu süreçte ne yapıldığı, nasıl basamaklarda öğretmenlerin ne görevler aldığını takip etmeleri gerekiyor. Benim okul müdürüm de konuyla ilgili süreç hakkında bana sorular sordu, son aşamaya geldiğimde bir teşekkür e-postası geldi. Bu da bir motivasyon kaynağı idi açıkçası.” (Interview_02-T22, Konum 43)

[150] “Bu durum tabiki pandemi sürecinden etkilendi. Sürekli bir değişiklik söz konusuydu. Bir evden çalıştık bir süre, sonra tekrar okula döndük. Ders saati sürelerimiz bir süre 30 dakika idi, sonra 40 dakikaya çıktı. Etütler planladık. Okul sonrası ev yaşantısı da sürekli bir kaos içindeydi. Şu anda okuldayız mesela, o süreç biraz daha toparlandı. Ama biz bu etkinlikleri yürütürken gerçekten kötü bir dönemdi bizler için.” (Interview_02-T05, Konum 40)

[151] “Seminer döneminde yapılsa daha verimli geçerdi kesinlikle. Çünkü öğretmenin eğitime katılımı bile kendi zamanından ayırarak planlaması gerekiyor.” (Interview_02-T02, Konum 47)

[152] “Katılımcı olarak kendimi düşündüğümde de, benim bu sene çok fazla bir yoğunluğum yok, yani bu sene çok fazla dersim yok açıkçası. O yüzden ben TÜBİTAK’a falan da hazırlandığım için biraz vaktim vardı. Yani benim için çok büyük bir sorun olmadı katılım sağlamak.” (Interview_02-T21, Konum 40)

[153] “Dediğim gibi ben gerçekten keyif aldığım için tekrar katılmak isterim. Çünkü bana çok şey kattı. (Interview_02-T08, Konum 48)

[154] “Belki uzun vadede bir şey yapılırsa katılırım ama kısa vadede bu yoğunlukta programa katılmak istemem. Çünkü çok ekstra zaman gerekiyor.” (Interview_02-T16, Konum 67)

[155] “Sen giriş kısmını yap, derdik birine. Bir diğerine gelişmeyi ve bir başkasına da değerlendirmeyi verebilirdik. Bu şekilde daha güzel ilerleyebilirdi. Bu ders planı geliştirme işini de bölümlere ayırıp, bir araya getirebilirdik.” (Interview_02-T22, Konum 35)

[156] “Orada etkileşimimiz tabii ki çok daha yüksek oluyor. Yüz yüzesiniz. 3 gün boyunca berabersiniz ve ortak bir ürün çıkartıyorsunuz.” (Interview_02-T10, Konum 55)

[157] “Önerilerde bulunurken rahattım, o pozitif ortam bence çok önemliydi, yaratıcılığı teşvik etmek anlamında.” (Interview_02-T01, Konum 52)

[158] “Evet çok fazla detay yoktu açıkçası. Hatta ben şunu söyleyebilirim. Ben bazen uzun uzun uzun yazdım. Sonra baktım yani çok uzatıyorum herhalde dedim. Cümleleri çoğu zaman kestiğim oldu. Diğer hocalarımızın paylaşımlarına bakarak. Yani bu birazcık çekingenlik mi bilmiyorum. Uzattığımı düşündüm açıkçası. Çoğu yorumu da sildim. Yani birazcık daha öz, kısa ve öz yazmaya çalıştım.” (Interview_02-T13, Konum 58)

[159] “Etkileşimler genel olarak iyiydi bence. Hepimize farklı bakış açılarını gösteriyordu. Hiç yapmış olmak için yapılmış gibi hissettiğim durumlar yoktu. Herkes içinden geldiğince yazmaya çalıştı. Hep de bir şeyler katmışlardı. Benim okuduklarım öyle şey değildi. Bakın böyle de düşünmüşler dediğim noktalar vardı hep. Hatta böyle kime katılıyorum ya da katılmıyorum diye baktığımda, şu cümleye çok katıldığım için kendime not almışım. “Ne yapacaklarını biliyorlar ama kodlamaya geçmekte zorlanıyorlar” Kafamda benim de tasarladığım ama cümleye dökemediğim bir ifadeydi. Genel olarak hem niceliği hem de niteliği açısından iyi bir etkileşim vardı (Interview_02-T11, Konum 61)

[160] “Yani uyguladıktan sonra bence onların da ilgisini çektiği için devamında. Hatta ilk zamanlarda pek katılım yoktu fark ettiyseniz, ama sonra daha fazla olmaya başladı. İlgilerini insanların çektikçe tabi katılım artıyor herhalde diye düşünüyorum.” (Interview_02-T04, Konum 42)

[161] “Tabii, bazen gruptan hiç ses çıkmaması konudan uzaklaşmanıza neden olabiliyor.” (Interview_02-T14, Konum 49)

[162] “Rutine bağlayabiliriz hocam. Zaman kavramında daha dikkatli olabiliriz. Örneğin, iki haftada bir süreç değerlendirme yapılabilir. Ne yaptık, ne yapıyoruz, neredeyiz? Rutin her zaman daha sağlıklı ilerliyor. Yani insanlar iki hafta öncesinden toplantısının olacağını bilirse, hazırlıklarını ona göre yapar. Bugün konuşacağız, der. Uygulamadığı bir şeyi uygular. Daha hazırlıklı olur.” (Interview_02-T12, Konum 51-52)

[163] “Yazışarak, platform üstünden bunları takip etmek, nihayetlendirmek çok zor oluyor. Dolayısıyla böyle bir çalışma yapılırsa daha sık toplantı konulabilir. Süreç daha kısa sürsün diye değil de, daha kısa sürerken daha etkili oluyor aslında. Çünkü ne kadar uzarsa siz o kadar varmak istediğiniz hedeften uzaklaşıyorsunuz, kafa olarak da çünkü olay büyüyor. Gözümüzde büyümeye başlıyor en başta. İlgi de azalabilir.” (Interview_02-T16, Konum 64)

[164] “Özellikle son toplanma da çok keyifli idi. Sanki acaba her etkinlik sonrası toplansaydık, biraz daha motive edici olur muydu diye düşündüm. Çünkü diğer

okullardaki arkadaşları görmek, onların çalışmalarını görmek de güzeldi fikir edinmek açısından ya da kendi grubumuza bakmamız açısından da önemli idi." (Interview_02-T05, Konum 54)

[165] "Belki bu platformdan bana çok bildirim gelmiyordu açıkçası. Belki onu bildirim gelir hale getirmek, hani yorum yapıldı size, hani oluyor ya böyle bildirim veriyor size, yorum yapıldı, beğenildi gibi bir bildirimler gelmesi iyi olabilirdi. Biraz daha mobil bir uygulama olsa belki çok daha rahat ederdik. Bu bildirime ihtiyaç duyuldu, bu da takibi zorlaştırdı. Hani ben ara ara kendime sürekli hatırlattım, hani gün içinde bakayım bir şey var mı takip etmem gereken?" (Interview_02-T01, Konum 56)

[166] "Mevcut kullandığımız öğretim yönetim sisteminden girip, sosyal gruplar kısmında kendi çalışma alanımıza girmek acaba biraz zor muydu? Bir kere yazdıklarımı kaydedememiştim. O nedenle önce yazacaklarımı kendim notlar kısmına kaydedip, sonra oradan kopyalayıp sisteme giriyordum. Bu yaşadığım aksaklık acaba insanların işlerini zorlaştırıyor mu? Benim gibi bu durumu yaşayan var mı diye düşündüm. Bunun da etkileşimi olumsuz etkileyebileceğini düşünüyorum." (Interview_02-T05, Konum 52)

[167] "Çünkü bir de ilk kez böyle bir eğitime katıldığım için, ben hani ne yapacağımı da tam kafamda oturtamadım." (Interview_02-T08, Konum 29)

[168] "Bir de tabi farklı kurumlardan olmamız, birbirimizi tanımıyor olmamız da insanların çekinmesine neden oldu. Belki aynı kurumda olsak daha ortak ve kolay bir şekilde bir şeyler çıkarabilirdik." (Interview_02-T22, Konum 41)

[169] "Bu araçlara uzak olmak özellikle Scratch'e… Yani ismini duyunca acaba yapabilir miyiz? Acaba ne yapmalıyız? Bu düşünce biraz yavaşlatmış olabilir bizi." (Interview_02-T07, Konum 52)

[170] "Bu okulda da bu sene benim ilk yılım, ben böyle etliye sütlüye karışmayayım modundaydım. Hiç cesaret edemedim açıkçası. Çok daha deneyimli hocalar olduğu için kurumda, yıllarca çalışan hocalar olduğu için çok daha faydalı olacaklarını da

düşündüm. Belki çok daha iyi bir şekilde yapabileceklerini de düşündüğüm için." (Interview_02-T08, Konum 37)

[171] "Herkesin bir görevi olsa sıkıntı yaşanmazdı. Birileri açıkta kalınca, bu sefer açıkta kalınmak istendi. Kişi sayısına görev görev versek daha iyi olabilirdi. Herkes görev almak zorunda olduğunu hissedince mecbur alırlardı." (Interview_02-T15, Konum 38)

[172] "Ben şöyle düşündüm, rol dağılımını aslında belki de yapmaya gerek yok, çünkü süreçte aslında herkes rolüne kendiliğinden bürünüyor gibi bir şey hissettim. Mesela daha çok grupta ben şeyi sorduğumu hatırlıyorum. Şu an hangi aşamadayız gibi? Zaman tutucu gibi bir şey olmuştum." (Interview_02-T01, Konum 44)

[173] "Ama bir noktada hepimiz koptuk yetişemediğimiz için. Ben kendim de etkinlikleri zamanında yapmakta zorlanırken, gruba hatırlatma yazma konusunda çekindim. Önce kendimin o etkinliği tamamlaması gerektiğini düşündüm, herkese hatırlatmak için." (Interview_02-T05, Konum 40)

[174] "Söylerken bile defalarca yazıp, üstünden geçip, nasıl yazsam, şunu mu koysam cümleye gibi kaygılarım oldu. Kimse yanlış anlamasın, emir veriyormuş gibi olmayayım diye…Biraz da yazı dilinin soğuk kalması da etkiledi." (Interview_02-T06, Konum 53)

[175] "Lider rolü görevini üstlendim ama öğretmenlerimizin genel yoğunluğu, istekli olmamaları vb. etkilerden dolayı çok etkili bir görev süreci tamamladığımı düşünmüyorum. Öncü olarak paylaşımlarda bulunmam ve gruptaki arkadaşlarımı da teşvik etmem gerekiyordu." (Interview_02-T20, Konum 31)

[176] "Takım oluştuktan sonra rollerin yeterli olduğunu düşünüyorum. Önemli olan o birlikte bir şey yapma ve başarma duygusuyla hareket etmek." (Interview_02-T20, Konum 37)

[177] "Mesela bir de o ismi ne olur bilmiyorum ama uygulayacağımız programa çok hâkim biri öğretmenlerle bireysel bir çalışma yapabilirdi. Sanki bir de ben

öğrenciyim, o öğretmen mesela bana bir program çalıştırıyor birlikte keşfederek. Belki böyle bir şey olabilir.” (Interview_02-T18, Konum 34)

[178] “Dediğim gibi bilişim teknolojileri öğretmenin olacağı bir rol, bunu bizlerle paylaşabilirdi.Böylece biz de 6. Sınıftaki öğrencilerin örneğin Excel ile ilgili neyi bilip, bilmediğini daha iyi anlayabilirdik. Bu doğrultuda hareket edebilirdik.” (Interview_02-T14, Konum 39)

[179] “Bir de süreçte zaman tutucu rolünde, sürekli bir takip gerekiyordu. Gün içinde, ya da o hafta kendi incelemenizi tamamlasanız bile grup arkadaşlarını kontrol etmek gerekiyor. Okul sürecinde buna zaman ayırmak çok zor. Bir de pandemide uzaktan eğitim sürecinde farklı bir gündeminiz oluyor.” (Interview_02-T02, Konum 43-44)

[180] “Yani böyle bir çalışma bir daha yapılsa belki şu yapılabilir. Grupta herkesin bir rolü olabilir. Çünkü orada bulunmayan veya bizim kadar buna zaman ayıramayan arkadaşlar oldu.” (Interview_02-T16, Konum 46)

[181] “Aslında başlangıçta ben nasıl bir şey ile karşı karşıya kalacağımı bilemediğim için nasıl bir görev bekliyor bizi çok kestiremedim. Aslında siz rolleri paylaştınız açıklamalarıyla ama… Sürecin nasıl olacağını çok bilmediğimden ve böyle bir etkinliğe daha önce katılmadığımdan görevleri üstlenmekten biraz çekindim açıkçası. Bence süreçte üstlenilecek rollerle ilgili biraz daha detay verilebilirdi. Başta sadece verilen şeyleri ismen algılayabildim ama tam olarak ne yapacağını anlayamadım verilen görev tanımlarında.” (Interview_02-T09, Konum 45)

[182] “Görevlerin paylaşıldığı toplantıda görevin detayları çok iyi oturmadığı için yeterli seviyede gerçekleştirebildiğimi düşünmüyorum.” (Interview_02-T02, Konum 43)

[183] “Belki rollerin daha detaylı tanıtıldığı bir toplantıya ihtiyaç vardı. Grubun kendi başına karar verme sürecini pekiştirirdi.” (Interview_02-T18, Konum 32)

[184] “Gönüllü öğretmenlerimize rol dağılımı yaptık ama sonrasında bu roller değişecek diye hatırlıyorum. Öyle bir değişim olmadı sanırım. Değişmesi daha iyi olabilirdi. Sürece herkes daha aktif katılmış olurdu.” (Interview_02-T13, Konum 41)

[185] “Sanırım bunu kural olarak bir ikinci etkinlikle değişecek diye koymak çok daha etkileyici olabilir. Aynen öğrencilere yapıldığı gibi büyüklere de böyle biraz keskin çizgilerle konuşmak gerekiyor.” (Interview_02-T16, Konum 48)

[186] “Belki şey de olabilir, bir akademisyenle de bir araya gelebilirdik. Belki en başta videoda anlatılan teori kısmını bize akademisyen anlatabilirdi. Hem bir tanışma-kaynaşma ortamı olabilirdi hem biz aklımızdaki soruları sorabilirdik. Neden yapıyoruz, niçin yapıyoruz gibi… Bu süreçte bizden tam olarak beklentiler nedir, ne değildir şeklinde… Bu eğitim programını bence daha da ciddileştirirdi, daha etkili kılardı. Biz her zaman her şeyi doğru yapan değilizdir, bir üstten de destek almak istiyoruz aslında. Bazen küçük yorumlar bile, keyifli hale getirebilirdi o planlarda. Bu bizim daha aktif rol almamızı ya da katılımcı olmamızı sağlayabilirdi. Ben nasıl çocuğa rehber oluyorsam, benim de bir rehbere o anlamda ihtiyacım oluyor.” (Interview_02-T22, Konum 48)

[187] “Başka grubun uygulamasını bizlere öğretmenlerin anlatmasından ziyade mümkün olabilen, belirlenen bir saatte bizim de gözlemci olarak katılabildiğimiz etkinlikler düzenlenebilir. Çünkü artık online her derse katılabiliniyor. Belki öğrencilerine yapılan bir sunuş sırasında bir ders izleme, değerlendirme anlamında değil elbette hani şunu nasıl yaptın, bunu nasıl yaptın diye değil. Gözlemleme anlamında, deneyimleme anlamında böyle etkileşim arttırılabilir diye düşünüyorum.” (Interview_02-T10, Konum 57)

[188] “Planlama ve uygulama arasında belki biraz zaman olabilir. Şöyle mesela, bu sene biz excel ve Scratch ile ilgili daha uzun süre çalışıp, neler yapabiliriz diye çalışabilirdik. Ders planlarını önümüzdeki sene uygulamaya alabilirdik ya da birinci dönem çalışıp, ikinci dönem uygulasaydık, o zaman süreç eminim daha hızlı ilerlerdi. Çünkü dönem ortasında başladık ekim ayında. Zaten süreç online, zaten çok değişiklik vardı ve çok zorlanıyorduk.” (Interview_02-T05, Konum 59)

[189] “Bir de bu çalışmada çok büyük bir gruptuk aslında. Kendi içimizde küçük gruplara ayrıldık. Belki de bu daha önce yapıldığı gibi, daha küçük bir katılımla pilot şekilde ilerleyebilir.” (Interview_02-T22, Konum 46)

[190] “Aynı okuldan en azından 2’şer öğretmen seçilebilir hem fikir paslaşması açısından hem birliktelik açısından.” (Interview_02-T22, Konum 46)

[191] “Orada bakış açımızın ne olduğunu gördük aslında. Yapılandırmacı yaklaşımı biliyoruz ama teknolojiyi entegre ederken nasıl ele almalıyız onu gördük.” (Interview_02-T14, Konum 27)

[192] “Ama asıl matematiği anlamak için bilişsel aracın nasıl bir etkisi olduğunu o örneklerde görerek anladık.” (Interview_02-T11, Konum 40)

[193] “Örnekler çok işe yaradı aslında. Çünkü buna benzer bir plan daha önce yapmadığınız için acaba nereden başlayacağım diye bir endişe oluyor. Ama önünüzde bir örnek olunca, size bir çağrışım yapabiliyor. Ya da siz de benzer şekilde bir günlük hayat örneği arıyorsunuz. O bilişsel aracı kullanırken, öğrencilere etkinlik kağıdında nasıl sorular yönlendirebileceğinizi görüyorsunuz. Nerede nasıl ipuçları verilebilir, onu görüyorsunuz. Öğrenciler grup olarak çalışırken, öğretmenin rolü ne onu görüyorsunuz. Baya yol gösterici oluyor örnekler. Biz sonuçta çok nadiren bu tür ders planları yapıyoruz. Aynı zamanda yeni bir teknolojik araçtan nasıl yararlanabileceğimizi görüyoruz. Modelin içindeki, her adım örneklerde belirtilmişti. Bizim için somutlaşmış oldu.” (Interview_02-T19, Konum 37)

[194] “Yani ders planı, ders planları örnekleri benim için çok etkiliydi. Yani bundan sonra da herhangi bir teknolojik araç kullansam da kullanmasam da ders planı örneklerini, bundan sonra ders planı hazırlama aşamasında kullanacağımı, planlarımı daha aktif hale getireceğimi düşünüyorum.” (Interview_02-T07, Konum 46)

[195] “Kesinlikle yol göstericiydi. Ben mesela sıfırdan başladım diyebilirim. Orada kullanılacak şeylerin tanıtılması, nasıl uygun kullanılacağının söylenmesi gayet yol göstericiydi. Ben orada izlediklerimle, tabii ki kendim de birazcık deneyip yanılarak bir ürün ortaya çıkartabilmiştim sonrasında.” (Interview_02-T10, Konum 43)

[196] “Ama tek başıma sıfırdan o programları yazamazdım o kadar. Hani sadece izleyerek onu yapamazdım. Onun için belki birkaç ay yoğunlaşıp programla uğraşmak gerekir. Ama gönderilen o taslak üstünden bilişim öğretmenimizle birlikte programı geliştirebildik. O zaman daha rahat anlaşıldı Scratch kullanımı.” (Interview_02-T01, Konum 40)

[197] “Dolayısıyla, bu eğitim kapsamındaki etkinlikler bize uygulamaya dair deneyimler kazandırdı. Bilişsel araç olarak kullanmak için bir aracı nelere dikkat etmeliyiz, dersi nasıl planlamalıyız, uygularken neler yapmalıyız gibi.” (Interview_02-T19, Konum 25)

[198] “Öğrencilere uyguladığım zamanda etkisini gördüm. Mesleki olarak bu konuda bilgi sahibi olmak da teknoloji kullanımında farklı örnekler inceleyip, uygulamış olmak çok katkı sağladı.” (Interview_02-T22, Konum 18)

[199] “Sonra da bize bir ödev verdi, kendiniz de hazırlayabilirsiniz diye. Orada adım adım yaparken ben de daha fazla keyif aldım. Ben de bir şey yapabildim diye düşündüm.” (Interview_02-T11, Konum 42)

[200] “Tabii, yine de kendi başımıza bir şey üretme kısmı zordu. Bu kısımda hem matematik öğretmenleriyle birlikte çalışmak hem de bilişim öğretmenlerinin olması biraz daha kolaylaştırdı. Tek başıma hemen yeni bir şey üretemezdim herhalde...” (Interview_02-T06, Konum 39)

[201] “Evet zümremizle zaten hep birlikteyiz, hep sürekli ekip çalışması içindeyiz onlarla. Ama bu benim için farklı bir ekip çalışması oldu. Grubumuzda farklı okullardan hocalarımızla çalışma fırsatım oldu. Onların bakış açılarını gördük, yeni fikirler ürettik.” (Interview_02-T12, Konum 22)

[202] “Şöyle, bu sürece denk gelmesi zorladı. Ben evden çalışıyorum, hani 2 öğretmenin iletişim halinde olması lazım. BT öğretmenimizle bir araya gelemedik. Hani okul ortamı olsa daha rahat edebilirdik. Yani o biraz zorladı ve süreci uzattı.” (Interview_02-T23, Konum 10)

[203] “Belki bilişim öğretmenleri de bu kazanım seçimi konusunda, onu nasıl ilişkilendirebileceğimiz konusunda destek olabilir. Çünkü grupta çok az bt öğretmeni aktif rol aldı. Sadece okulda kendi içimizdeki planlamalarımızda destek verdiler. Aslında o toplantılarda aktif katılımları olsaydı, belki çok daha hızlı karar verebilirdik.” (Interview_02-T19, Konum 61)

[204] “Fikir beyan eden öğretmenlerimin çok değerli katkıları vardı. Kendi tecrübeleri ve kendi okullarından da getirdikleriyle… Bu tabi ki olumlu olarak etkiledi.” (Interview_02-T06, Konum 61)

[205] “Geliştirdiğimiz ders planını herkes kendi okulunda uyguladığında da bu sefer neyi aynı yaşadık, aksaklıklar yaşandı mı veya benzer kolaylıklar yaşandı mı, onları görmüş olduk. Farklı etkinlikler yerine böyle tek bir etkinliğin üzerinde yoğunlaşmak daha mantıklı geldi bana.” (Interview_02-T09, Konum 26)

[206] “En güzeli de aslında herkesin o ders planlarını yaşadıktan sonra paylaşımlarıydı. O deneyim sonrası, bu böyle denmesi bizim için nokta atışı oluyor. Gerçekleştirilmiş olması bize daha da çok bilgi veriyor.” (Interview_02-T11, Konum 56)

[207] “Yani bazen kendi okulumuzda böyle bir ekip olmuyor. Dolayısıyla diğer okullarla aramızda böyle bir iletişim sağlayıp oradaki uygulamaları da dinlemek ya da fikirleri duymak bile bize bir yol gösteriyor, bir fikir… Yani bir şevk oluyor en azından, a o okul yapmış, böyle olmuş. Bizde de neden olmasın? Bir şevk oluyor yine işimize karşı.” (Interview_02-T18, Konum 26)

[208] “Benim bakış açımı da genişletti, ufkumu da genişletti. Yani çok dar şeylere sıkışıp kaldığımı fark ettim mesela ben. Birkaç tane uygulamaya sıkışıp kalmışım. Ama çok daha farklı uygulamalarla, farklı çalışmalar yapabileceğimi gördüm.” (Interview_02-T08, Konum 48)

[209] “Aynı zamanda bilişsel araç olarak da kullandığım bir örnek yokmuş. Benzer olarak, bazı konularda öğrencinin anlamasını kolaylaştırmak için teknolojiden yararlanıyordum. Ama bu çalışmalarda, öğrenci bir ürün üretmiyordu ya da bilişsel

araç kullanımında çalıştığımız ders planları gibi detaylı bir planlama süreci yoktu." (Interview_02-T02, Konum 18)

[210] "Ben kendi adıma teknolojik anlamda da aslında bir şeyler yapılabileceğini, matematikte de çok zor olmadığını gördüm." (Interview_02-T09, Konum 3)

[211] "Eğitim programı, bildiğimiz programları, Excel ve Scratch gibi, matematik ile bağdaştırmamızda kolaylık sağladı." (Interview_02-T20, Konum 4)

[212] "Kendim zaten kullanıyormuşum, tablo oluştururken, çocukları değerlendirirken. Onu fark ettim. Fakat bunu eğitime dökmek, exceli eğitimde kullanmak… Beni en çok heyecanlandıran kısmı bu oldu. Herkesin bildiği şeyleri, mutfaktaki malzemeleri tezgaha koymak ve bir şeyler ortaya çıkarmak bence keyifliydi." (Interview_02-T06, Konum 25)

[213] "Ben Scratch'i zaten bilmiyordum program olarak. Excel'i mesela, evet kullanıyormuşum, ama matematiksel yanını hiç düşünmüyormuşum." (Interview_02-T18, Konum 14)

[214] "Teknolojinin sadece eğlence amaçlı ya da çocuklara farklılık olsun diye uyguladığımız bir şey olduğunu ben kabul edememiştim. Bu benim hep sorguladığım bir şeydi. Tamam, teknoloji çok güzel ama kullanmış olmak için kullanmayalım. Ya da sadece eğlence amaçlı kullanmayalım dediğim bir noktadaydı. Bu fikirde olduğum için de çok heyecanlandırdı beni. Aslında gerçekten teknolojinin matematiğe hizmet edebileceğini, exceli nasıl yapabilirim, scratchi nasıl yapabilirim diye denedik ve gördük." (Interview_02-T05, Konum 4)

[215] "Teknolojiyi dahil ederken daha önceki derslerimde bu kadar bütünsel ele almıyordum. Araçların özelliklerinden yararlanıyordum sadece." (Interview_02-T02, Konum 4)

[216] "Tabiki teknolojinin ucu bucağı yok. Çok farklı programlar var. Ama doğru teknolojiyi doğru yerde kullanmak, doğru programı kullanmak önemli olan." (Interview_02-T22, Konum 7)

[217] "… teknoloji konusunda çok iyi olduğumu düşünüyordum. Ama fark ettim ki, o kadar değilim." (Interview_02-T05, Konum 6)

[218] "Hala da eksiklerim çok var ama bir bakış açısı kazandık. Bunun çok da zor olmadığını gördük. Biraz ilgilenmek gerektiğini gördük." (Interview_02-T11, Konum 69)

[219] "Ama öncesinde bir planlama gerektiğini hatta çok iyi bir planlama yapmak gerektiğini tabii ki gördüm." (Interview_02-T09, Konum 3)

[220] "Haftalık planlarımı kazanımı bitirip, bitirmeme durumuna bakıyordum ve peş peşe yazıyordum. Şimdi ders ders bölmeye başladım. Bu benim için etkili oldu." (Interview_02-T06, Konum 27)

[221] "Özellikle işte etkinlik kâğıdı oluştururken örneğin, bir ders planı içerisinde etkinlik kâğıdı oluştururken, bizim bu uygulamaları yaparken gördüğümüz ders planları bana örnek oldu. Hemen zaten kaydettim bunları. Bundan sonra herhangi bir ders planı oluştururken mutlaka oradan da yararlanacağım. Jonassen'ın yapılandırmacı yaklaşımını temel alarak, etkinlik kağıdını o şekilde oluşturabileceğimizi…. Yani zaten kullanıyorduk ama bu kadar etkin kullanmıyorduk, bu kadar verimli olmuyordu tam olarak." (Interview_02-T07, Konum 23)

[222] "Biraz daha aslında hevesim arttı, şevkim arttı. Teknoloji kullanma konusunda motive oldum diyebilirim." (Interview_02-T12, Konum 6)

[223] "Az önce de bahsettiğim gibi, pandemi öncesinde teknolojiye bakış açım ile şu andaki bakış açım oldukça farklı. Bu nedenle de eğitime daha fazla ilgi gösterdim." (Interview_02-T06, Konum 7)

[224] "öyle değişen kısım daha fazla teknoloji kullanmaya karar verdim. Çünkü gerçekten bilişsel araç olarak kullanılabiliyor. Yani öncesinde biz bir şeyler yapıp çocuklara gösteriyorduk. Artık çocukların yapmasını sağlıyoruz." (Interview_02-T14, Konum 4)

[225] “Konuştukları teknoloji diliyle matematiği ilişkilendirebilmeleri bizim için avantaj. Bizim de o dile alışmamız lazım.” (Interview_02-T09, Konum 7)

[226] “Sonuçta teknoloji özellikle bu pandemiyle birlikte vazgeçilmezimiz durumunda. Belki kullanıyorduk ya da bazı branşlar daha aktif kullanıyordu. Ama şu anda artık olmazsa olmaz noktasındayız. Buna direnmek mümkün değil, şu anki yaşadığımız süreçte.” (Interview_02-T22, Konum 7)

[227] “Ama ders planı hazırlama sürecini düşündüğümde, bahsettiğim araçları genelde sınıf içinde o dersi ne kadar anladıklarını kavramak için yani ölçme ve değerlendirme için kullanıyordum. Ya da bir derste girişte neler biliyorlar diye kontrol ediyordum.” (Interview_02-T02, Konum 18)

[228] “Yani çok nadiren Kahoot kullanıyordum ama, o da yani hani çok efektif olmuyordu.” (Interview_02-T24, Konum 15)

[229] “Yani muhakkak teknolojiyle birlikte gideceğiz. Ama ne kadar kullanacağım ne boyutta, hangi konuda, çok şu an planını yapmış değilim açıkçası. Biraz bıkkınlıktan da kaynaklı olabilir.” (Interview_02-T16, Konum 8)

[230] “Ama şimdi okulca ya da yönetimce düşündüğümüzde tabii ki bu teknoloji kesinlikle artık çıkmayacak hayatımızdan. Mesela bir kar tatili vardı eskiden, artık yok. Artık direkt online olacak. Yani bu, hani bir şekilde teknoloji ile eğitime devam edilecek.” (Interview_02-T16, Konum 8)

[231] “Evet teknolojiyi kullanıyoruz ama teknolojiyi derste akıllı tahtanın video izleme özelliğini kullanarak kullanıyorduk.” (Interview_02-T07, Konum 17)

[232] “Yani Excel’i daha çok ben şeyde kullanıyordum, grafik. Mesela şu an veri toplama konusundayız. Orada onların tablolarını, sütun grafiklerini oluştururken Excel’i, Word’ü ya da orada grafikleri kullanıyorduk zaten.” (Interview_02-T01, Konum 19)

[233] “En fazla 8'lerde, geogebrayı tahtaya yansıtıp, tüm sınıfa pergel dağıtıp üçgen çizimi, açı kenar bağıntısı gibi konularda etkinlikler yapıyorduk.” (Interview_02-T11, Konum 29)

[234] “O programda, öğrencilere çeşitli uygulamalar yaptırabiliyoruz. Öğrenciler, değişkenleri kendileri belirleyebiliyor ve uygulamalarının sonuçlarını gözlemleyebiliyor… Ama bu çalışmadaki gibi öğrenci kendi bir ürün de üretmiyor.” (Interview_02-T09, Konum 23)

[235] “Öğrenciye o anda öğrenmiş olduğu bilgiyi kullanmayı ve uygulamayı sağlıyor.” (Interview_02-T09, Konum 23)

[236] “Orada öğrenciler Canva’da afiş ve benzeri tasarlayabiliyorlardı. Ama biz dersimizde şöyle bir plan yapmıştık. Öğrenciler, matematik dersinde öğrendikleri kümelerde kesişim konusuna kendileri bir günlük hayat örneği oluşturacaklardı. Sonra o gerçek hayatta karşılaştıkları örneğin Venn şemasını Canva’da oluşturup tasarlayacaklardı. Bu doğrultuda, bize çok güzel örnekler geldi.” (Interview_02-T05, Konum 14)

[237] “Aslında bu eğitim küçük bir deneme gibi oldu. Ders planını oluşturduk ama sınıfta da nasıl gitttiğini gördük.” (Interview_02-T05, Konum 30)

[238] “Bence çok daha verimliydi. Yani böyle bir saatte evet hepsi konuşulabilir ama uygulamadan gerçekten anlayamıyorsunuz. Yani uygulamak lazım.” (Interview_02-T08, Konum 41)

[239] “Daha önce katıldığım eğitimlerde bunlar bunlar kullanılabilir diye bize sayıyorlar, şu amaçla veya bu amaçla kullanılabilir diye. Ama biz tekrar kendimiz açıp baktığımızda ne, nasıl diye kendi branşımızda düşündüğümüz noktalar oluyor. Orada aslında programın ismi yabancı gelince evet kullanabiliriz ama nasıl kullanacağız soru işareti oluyor ve öyle kalıyor.” (Interview_02-T07, Konum 61)

[240] “Ben biraz açıkçası bu konuda sosyal medyayı çok kullanıyorum. Yani meslektaşlarımın yaptıkları uygulamaları takip ediyorum ve zaman zaman onlar da eğitim düzenliyorlar. Beraber buluşup hatta, orada uygulamaları öğreniyorum. Özellikle bu Apple’ın uygulamaları için Apple Teacher’lar eğitimler düzenliyorlar, onlara katılmaya çalışıyorum. Veya kendi derslerinde kullandıkları güzel uygulamaları paylaşıyorlar, keşfettikleri.” (Interview_02-T01, Konum 23)

[241] “Her bir çalışma bir diğeri için ön hazırlıktı. Eğitim olmasaydı belki direk örnek ders planı incelemiş olsaydık daha çok zorlanırdık. Her biri çok kıymetliydi.” (Interview_02-T03, Konum 32)

[242] “Bu aşamalar, öğrenme süreci için çok değerliydi. Sıralama çok doğruydu… Bir önceki yıl katıldığım konferansta, bu adımlar hep çok eksikti. Bizden yine ürün bekleniyordu. Ama ürünü oluşturmadan önce ne istendiğini iyice anlamak, örnek görmek ve birlikte çalışmak bölümleri eksikti.” (Interview_02-T11, Konum 31)

[243] “Süreç aslında o kadar güzel ve her ne kadar pandemiye rağmen biraz uzasa da o kadar yolunda gitti ki her şey.” (Interview_02-T17, Konum 53)

[244] “Ayrıca tüm program boyunca, pandemi koşullarına göre gerekli esneklikler de sağlandı. Eğer sağlanmasaydı ve bu adım adım ilerleme mantığı kurgulanmış olmasaydı, kesinlikle bıkardık ve süreci takip edemezdik.” (Interview_02-T11, Konum 31)

[245] “O programı bilip araştırdıktan sonra nasıl yapabilirim kısmına dair planlama ve fikir aşamasında daha yaratıcı olabileceğimi düşünüyorum. Daha uygulanabilir şeyler bulabileceğimi düşünüyorum.” (Interview_02-T17, Konum 24)

[246] “Ama ben onlara bir program yazdıracaksam, önce benim yazmam gerekiyor. Scratch’e çok hakim olmam lazım. Bunun için çok zaman ayırmam lazım. Daha pratik uygulamaları tercih ediyorum doğal olarak. Excel bu anlamda bizim için daha kolaydı.” (Interview_02-T01, Konum 60)

[247] “Eğitim programı, bildiğimiz programları, Excel ve Scratch gibi, matematik ile bağdaştırmamızda kolaylık sağladı.” (Interview_02-T20, Konum 4)

[248] “Bu konuda kendimi çok yetersiz hissediyordum ve nasıl olacak, yapabilecek miyiz gibi kaygılar çok yoğundu.” (Interview_02-T24, Konum 2)

[249] “Sınıf yönetimi açısından da okuldaki ortam çok daha farklı oluyor tabii ki. Hani biz ne kadar öğrenciyi kamerayla takip ediyor olsak da, arka planda bazen hani bilemediğimiz şeylerde yapılabiliyor.” (Interview_02-T09, Konum 13)

[250] “ikili gruplar yaptık ama bazılarının mesela bilgisayarın da program yoktu. Tabletten ya da telefonundan katılmak zorunda kalan o ilk haftalarda o öğrencilerimiz biraz zorlandı. Hani diğeri birazcık daha lider gibi oldu. Yani birbirlerine evet yardımcı oldular ama birisi bir tık geride kaldı.” (Interview_02-T13, Konum 17)

[251] “Online ortamda olunca, ders süreleri biraz kısaldı onun da yarattığı bir baskı var.” (Interview_02-T05, Konum 59)

[252] “Bu planı oluşturma kısmı aslında işin belki de yüzde sekseni, çok önden bir planlama yapmanın çok önemli olduğunu fark ettim.” (Interview_02-T08, Konum 19)

[253] “Ama öncesi, yani ön hazırlığı, BT öğretmeniyle birlikte çalışma, hazırbulunuşluk için planlama yapma gibi şeyler de çok zaman ve emek isteyen şeyler.” (Interview_02-T22, Konum 44)

[254] “Buna çok katılıyorum ama bir anlamda da giden müfredat var. Bu bakış açısıyla müfredat birbirine uyuşmuyor.” (Interview_02-T11, Konum 26)

[255] “Bir yandan da müfredatta da geriden gidiyordum pandemi nedeniyle.” (Interview_02-T05, Konum 18)

[256] “Dolayısıyla bu baskı, beni şuna yönlendiriyor. Bu tür etkinlikleri yapmak yerine ben işte şurada şu soruyu çözeceğim dediğim anlar oluyor. İnanın oluyor yani. Conk üzerimizde o noktada müthiş bir baskı var hem veliden hem okuldan. Bu değişmeyen fikrim oluyor mecburen, yani sistem baskısı yüzünden sadece soru çözmeye odaklanmak…” (Interview_02-T19, Konum 5)

[257] “Ama öğrenciler açısından olumsuz olarak şunu söyleyebilirim, bilişim teknolojilerinin ders saati çok değil ve pandemi sürecinde de öncelikle ders programına ana dersleri yerleştiriyoruz okul olarak.

Bu nedenle de öğrencilerin bu anlamda yeterli olmalarında sıkıntılar yaşamamızın en büyük sebeplerinden birinin bu olduğunu düşünüyorum.” (Interview_02-T09, Konum 17-18)

[258] “Çoğu zaman BT öğretmenimizi göremiyorum haklı olarak. Yoğun, çok her kademeye de giriyor. Dolayısıyla çok zor görüşebiliyoruz.” (Interview_02-T11, Konum 2)

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