Education and Science

Vol 48 (2023) No 216 1-38

Original Article

5E Learning Cycle Supported Mathematics Digital Worksheets in Primary Schools: A Case Study

Seher Esen [1], Sümeyra Geçer [2], Hatice Çetin [3]

Abstract

This study, seeking to reveal in-service and pre-service primary school teachers' opinions and practices regarding the 5E learning cycle supported digital worksheets (5E-DWS) they created on GeoGebra, employed the case study design, a qualitative research design. Face-to-face interviews were held with six in-service and six pre-service primary school teachers regarding 5E-DWS in the study. Additionally, 10 5E-DWS documents, prepared by the participants, were analyzed. The research data was analyzed with the inductive analysis method. The participants referred to the preparation process of 5E-DWS and highlighted its digital features, constructivist nature and appropriateness for contemporary approaches. Based on the participants opinions, the analyses revealed that 5E-DWS is advantageous in that it concretizes mathematics, intrigues students, saves time and paper, activates learning-teaching process, removes misconceptions, fosters individual and learning by doing-experiencing, and contributes teachers' professional development. Its disadvantages include lack of technological equipment, inadequate teacher and student readiness, need for control, and individualizing students through blocking interaction with others. The study also elicited in-service teachers' experiences regarding their practice of 5E-DWSs in classrooms. They stressed that, compared to pen-and-paper worksheets, 5E-DWSs are more economical and sustainable, intriguing, fun, appropriate for the digital age and new generation students, and they provide an explorative and gradual learning environment. In the process of preparing 5E-DWS, the participants had the most difficulty and enjoyment in the same phases of 5E learning cycle, exploration and elaboration. Regarding the contents of the 5E-DWSs, the participants used different methods and techniques and various technological materials in each phase.

Keywords

Digital worksheet
5E learning cycle
GeoGebra
Mathematics

Article Info

Received: 02.16.2022
Accepted: 01.06.2023
Published Online: 09.29.2023

DOI: 10.15390/EB.2023.11645

[1] Selçuk University, Faculty of Education, Department of Primary Education, Turkey, seheresen42@gmail.com
[2] Necmettin Erbakan University, Graduate School of Educational Sciences, Department of Basic Education, Türkiye, sumeyragurbuzer@gmail.com
[3] Necmettin Erbakan University, Ahmet Keleşoğlu Faculty of Education, Department of Basic Education, Türkiye, haticecetin@erbakan.edu.tr

Introduction

The Ministry of National Education (MoNE) in Turkey initiated efforts for an effective and efficient education model, and introduced radical curricular revisions in 2005 (MoNE, 2005). This curriculum, based on the constructivist education approach, offers an activity-based learning environment to ensure students' active participation (Gültekin, 2020). Active learning, referred to as learning to learn and teach (Arslan, 2016), is the ability for the individual to construct knowledge effectively and efficiently and perform learning activities (Jayawardana, Hewagamage, & Hirakawa, 2001). Teachers should assume a guiding role in active learning environments and offer students opportunities to undertake responsibilities and acquire abilities for learning to learn (Felder & Brent, 1996; Lee, 1999; Michael, 2006).

These learning environments and learning experiences have been designed in line with constructivist learning approach recently (Noddings, 1990; Selley, 2013). The learning processes based on this approach include the 5E learning cycle model (Jones & Brader-Araje, 2002; Ulaş, Sevim, & Tan, 2012). The 5E learning cycle model (engagement, exploration, explanation, elaboration, evaluation) helps students learn concepts profoundly (Bybee & Landes, 1990), and ensures them to gain active research skills, needed for knowledge and comprehension during the learning process, and explore new knowledge through associating their existing knowledge with new knowledge (Wilder & Shuttleworth, 2005). This model encourages students for thorough learning by constructing their own knowledge in the guidance of teachers (Bybee et al., 2006). The name of the 5E learning cycle model consists of the initials of five phases. These phases include engagement, exploration, explanation, elaboration, and evaluation (Bybee, 2014). In the *engagement* phase, the teacher introduces the subject with a real-life problem or stimulating material that arouses students' attention and curiosity. In the *exploration* phase, students actively participate in activities in their teacher's guidance. In this phase, students are offered conceptual learning opportunity, and they interact with materials and hence explore and interpret the subject themselves. In the following *explanation* phase, students are asked to compare the knowledge they obtained in the previous phases with the teacher's definition. Thus, misconceptions are avoided. In the *elaboration* phase, students implement the new knowledge by associating it with real-life problems and offer remedies for these problems. Additionally, the teacher can initiate a new research activity for students to reinforce mathematical concepts. The final phase, *evaluation*, fosters students to evaluate their own understanding and skills. Besides, teachers also evaluate students' progress in the learning process and their learning outcomes. As a consequence, students actively construct knowledge in all phases (Bybee, 2014; Goldston, Day, Sundberg, & Dantzler, 2010; Ulaş et al., 2012). The 5E learning cycle is often used in science teaching, but other disciplines can also make use of this learning model (Bybee et al., 2006). Mathematics teaching supported with the 5E learning cycle contributes to students' academic performance (Bahtaji, 2021; Tezer & Cumhur, 2017) and positive attitudes towards mathematics (Turan & Matteson, 2021). Another study based on 5E learning cycle reported that students used GeoGebra software actively and their mathematical reasoning improved (Demir, Zengin, Özcan, Urhan, & Aksu, 2022). On the basis of mathematics instruction supported with the 5E learning cycle, research revealed that well-planned learning environments, and well-designed guiding materials enhance the effectiveness of mathematics lessons (Bilgin & Acar, 2007; Boztaş, 2012; Norton, 2001; Sezgin Memnun, 2007).

One of the significant materials that support learning environments and instruction in mathematics education is the worksheets (Dwijayani, 2019). The worksheets, used widely in mathematics instruction, are the materials that can be used for evaluation and reinforcement regarding a topic (Anderson, 1995) and help students construct their knowledge (Kurt, 2001). Besides, students may also need worksheets with "teaching" purposes. When designed for teaching, worksheets enable students to focus on various characteristics of texts, organize and construct materials and thus participate in learning experiences cognitively and critically (Paterno, 2009). Used for developing concepts and learning processes, worksheets prompt students (Muskita, Subali, & Djukri, 2020). Concordantly, digital worksheets are prepared in technology-supported digital environments.

Digital worksheets are efficient learning tools that allow interactive conceptual learning in a dynamic setting without the need for teachers (Lindenbauer, 2020). Unlike pen-and-paper worksheets, digital worksheets are instruction materials offering students visual and audio contents such as sound, videos, or images (Sujatmika vd., 2019). The active learning environments have transformed into interactive learning environments thanks to rapid developments in technology (Arslan, 2016), and teachers have started to prefer digital resources in their teaching practices (Serth, Teusner, Renz, & Uflacker, 2019). Indeed, compared with traditional (pen-and-paper) worksheets, digital worksheets can be adapted to students' learning needs (Serth et al., 2019). Accordingly, unlike the digital native children born and raised in the digital era, today's teachers were not born in the digital era, and they are not prone to digital technology since they met with computers at one point in their lives, hence called as digital immigrants (Wang, Myers, & Sundaram, 2013). These teachers need to change to be able to reach today's children (Prensky, 2001).

The materials prepared using technology, which is used in the learning and teaching process and has become one of the powerful sources of learning (Arbain & Shukor, 2015), have a positive effect on mathematics teaching (Dwijayani, 2019). Accordingly, several technology-supported software programs have been developed that enable preparing various materials in digital environments for mathematics instruction (Hohenwarter, Hohenwarter, & Lavicza, 2010; Hohenwarter & Jones, 2007; Majerek, 2014). One of these programs in which digital materials can be designed using technology and computer applications is GeoGebra. Using GeoGebra, a dynamic mathematics software, users can prepare and visualize the multiple representations of mathematical concepts as well as creating dynamic worksheets (Haciomeroglu, Bu, Schoen, & Hohenwarter, 2009). Recent research points that the digital worksheets created through GeoGebra are effective in mathematics instruction (Dwijayani, 2019; Güven & Yılmaz, 2012).

A review of related literature suggests that the research studies addressing 5E learning cycle supported worksheets were carried out with teachers and students that are in different school levels than primary school level (Er Nas & Çepni, 2011; Kolomuc, Ozmen, Metin, & Acisli, 2012; Töman, Akdeniz, Odabasi Çimer, & Gürbüz, 2013; Ulaş et al., 2012), indicating that research on this subject is inadequate for primary school level. Although in different school levels, existing research shows that worksheets developed based on 5E learning cycle improve students' performance and make the lesson more appealing for students (Kolomuc et al., 2012; Töman et al., 2013; Ulaş et al., 2012). Studies on the effectiveness of worksheets that were not based on 5E learning cycle also reported positive effects (Celikler & Aksan, 2012; Özmen & Yıldırım, 2005; Yoma & Armiati, 2018; Yulianti, 2017). Although there was one study reporting the effectiveness of worksheets at the primary school level, it was conducted in the field of science teaching (Syamsu, Rahman, & Kade, 2017). This review ofliterature reveals the gap for research on worksheets in the field of mathematics education and at the primary school level.

There are studies on digital worksheets prepared using technological software in different fields and levels (Demirci, 2019; Erna, Elfizar, & Dewi, 2021; Lindenbauer & Lavicza, 2021; Sari, Widiyawati, Nurwahidah, Masykuri, & Budiyanto, 2021; Serth et al., 2019; Suhendi, Jamilah, Mulhayatiah, & Ardiansyah, 2019; Susila, Chanifah, & Delina, 2021; Wibawa, Cholifah, Utami, & Nurhidayat, 2018). In the related literature, there are studies showing that the use of worksheets prepared using technology results positively in terms of learning environments (Arifin, 2014; Bakri, Permana, Wulandari, & Muliyati, 2020; Ichsan et al., 2020; Ito, Morimoto, & Hayakawa, 2018; Lestari, Miriam, & Misbah, 2021; Lupi, Herlina, Sesunan, & Andra, 2021; Mahtari, Wati, Hartini, Misbah, & Dewantara, 2020; Salim, Darmawan, & Jainuddin, 2021; Serth et al., 2019; Sholikhah & Cahyono, 2021). Serth et al. (2019) argued that worksheets developed through technological software allow students to learn at their own pace and encourage deliberate intervention by teachers. Erna et al. (2021) emphasized that digital worksheets contribute to the development of critical thinking skills. On the other hand, Suhendi et al. (2019) found that there was no difference in the problem-solving skills of students using digital worksheets and students using pen-and-paper worksheets. Additionally, there are studies on worksheets related to mathematics education (Martin, Irwan, Elniati, & Djuandi, 2017; Yoma & Armiati, 2018). While Martin et al. (2017) emphasized the effectiveness of worksheets in mathematics teaching, Yoma and Armiati (2018) focused on creating inquiry-based worksheets to develop eighth grade students' mathematical critical thinking skills. This review demonstrates that though the related literature is abundant, studies addressing digital worksheets at primary school level are highly limited.

There are some studies on worksheets prepared using GeoGebra dynamic mathematics software; however, these studies are not at primary school level (Baltacı, Yıldız, & Kösa, 2015; Çetin, Erdoğan, & Yazlık, 2015; Dwijayani, 2019; Güven & Yılmaz, 2012; Kutluca & Zengin, 2011; Shadaan & Leong, 2013), indicating that the studies using GeoGebra software also focused on other school levels than primary school level. Furthermore, several studies on GeoGebra software addressed teachers working at middle school and high school level (Kasti & Jurdak, 2017; Mingirwa, 2016; Surynkova, 2020). These studies reveal that GeoGebra software is effective and useful in mathematics teaching and that it supports students' concept learning and improves their academic achievement. The researchers observed that the studies in which technological learning environments prepared using GeoGebra software were presented and investigated were conducted with teachers and students beyond the primary school level.

In addition to these studies, there are studies in which GeoGebra software was examined with the participation of in-service and pre-service primary school teachers (Özçakır Sümen, 2017; Žilinskiene, 2014; Žilinskiene & Demirbilek, 2015). These studies reveal that GeoGebra software can have positive effects at primary school level according on teachers' views (Özçakır Sümen, 2017), but teachers are not adequate in terms of creating materials on GeoGebra software (Žilinskiene, 2014; Žilinskiene & Demirbilek, 2015). The researchers concluded that these studies conducted to determine the reflections of GeoGebra at the primary school level do not provide adequate insight for the relevant literature. Yohannes and Chen (2021) attributed this inadequacy to the lack of adequate and relevant training for teachers in technology-enhanced mathematics teaching. In this respect, it is recommended to conduct different studies in which GeoGebra software is evaluated from the perspective of primary school mathematics teaching (Yohannes & Chen, 2021; Žilinskiene & Demirbilek, 2015). It is thought that examining in-service and pre-service primary school teachers’ views on their experiences of GeoGebra in the material design process might contribute to the literature on primary school mathematics education. Additionally, a review of studies at primary school level reveals that the 5E learning cycle and materials designed through digital software are not frequently used in mathematics. In line with all these results, in order to provide more insight to the field, it is vital to examine the experiences gained through the design of digital worksheets supported by the 5E learning cycle model using GeoGebra software at primary school level with regard to the views of in-service and pre-service primary school teachers. Hence, the current study differs from the studies in the literature since it examines the practices based on digital worksheets supported by the 5E learning cycle model using GeoGebra software at primary school level and obtaining opinions from practitioners. The present study aims at examining the opinions and practices of in-service primary school teachers attending postgraduate education and pre-service primary school teachers attending undergraduate education regarding the digital worksheets prepared based on the 5E learning cycle model (5E-DWS) within the scope of the courses they take.

To this end, the research questions are as follows.

1. What are the participants' opinions about the 5E-DWS they prepared?
2. What are the participants' preferences regarding the mathematics learning domains and subjects in which the 5E-DWS they prepared are used?
3. What are the participants' opinions about the advantages and disadvantages of 5E-DWS?
4. What are the participants' opinions about the differences and similarities between 5E-DWS and pen-and-paper worksheets?
5. What are the participants' opinions about the phases of 5E learning cycle during the process of preparing 5E-DWS?
6. What are the in-service teachers' opinions about their experiences regarding the application of 5E-DWS they prepared in the classroom environment?
7. What are the participants' practices regarding the contents of 5E-DWS they prepared?

Method

Research Design

This study examines in-service and pre-service primary school teachers' opinions about 5E-DWS. Therefore, the current study employed the qualitative research method (Sönmez & Alacapınar, 2019). Qualitative research is a research method used when there is limited knowledge about the basic phenomenon of the study, and it enables collecting more data from the participants about this phenomenon (Creswell, 2020). This study employed the case study method out of qualitative research designs which emphasizes understanding, defining, predicting, or controlling an individual, group or cultural case (Akar, 2016). In case studies, one or several cases are investigated with a holistic approach and the focus is on how they affect the relevant case and how they are affected by the relevant case (Yıldırım & Şimşek, 2021). Accordingly, this study was designed in line with the case study design to reveal the participants' experiences, practices, preferences regarding the 5E-DWSs they prepared using the GeoGebra software and the effects of the process in a holistic way. In case studies, it is important to explain the relevant case and its boundaries (Creswell, 2019). Accordingly, the case of this study can be defined as the participants' experiences and implementation processes of the 5E-DWSs they prepared with the GeoGebra software within the scope of the course they took during a semester. In this regard, an experience-based case study should be planned, and the researcher should set out by deciding whether to examine an individual or a program, a process in practice or a policy (Akar, 2016). As Yıldırım and Şimşek (2021) state, cases that no one has studied or reached before can be studied using a holistic single-case design. Accordingly, the current study was conducted relying on the experience-based holistic single-case design, involving the participants' processes of preparing and implementing the 5E learning cycle-supported digital worksheets within the scope of the course they took in their undergraduate and graduate education.

Participants

The working group of this qualitative research study was selected using the purposive sampling method. Qualitative studies typically focus on a relatively small sample selected purposefully or even on a single case. The logic and power of purposive sampling lies in selecting information-rich situations for in-depth study (Patton, 2018). In order to ensure that this research provides information-rich content, the maximum variation sampling strategy was used. Maximum variation sampling is a purposive sampling method in which the researcher identifies individuals or cases differing in terms of certain characteristics, criteria and qualities and includes them in the sample group (Creswell, 2020; Patton, 2018). In this study, six in-service primary school teachers studying postgraduate education (non-thesis master program) and six pre-service primary school teachers studying undergraduate education were purposively selected. In the selection of the participants, who took an active role in the process of preparing 5E-DWS within the scope of the course, the opinions of the course instructor were resorted, and the study was conducted with the volunteering in-service and pre-service primary school teachers. In addition, the number of participants who volunteered to participate in the study was effective in the selection of in-service and pre-service primary school teachers separately. The experiences of the in-service primary school teachers who implemented the 5E-DWS in their classrooms regarding the implementation processes were analyzed in line with their opinions. Except from this, all participants' opinions were collectively analyzed since the other research questions involved the implementations in the course they took. In the selection of the participants, the researchers paid attention to the socioeconomic and socio-cultural diversity of the school district where the primary school teachers worked, and to the diversity of the teachers' age levels and years of seniority in order to obtain different opinions. Opinions on the 5E-DWSs designed using a technological software were evaluated according to these criteria. The sample of pre-service teachers was selected based solely on volunteering principle without paying regard to other criteria. The sample group was expanded until the data reached saturation point and the data collection process continued until the data started to repeat itself. The concept of saturation in the data collection process in qualitative research offers a comprehensive way to think about sample size (Creswell, 2019).

The participants prepared the 5E-DWSs in GeoGebra, the dynamic mathematics software they learned in the course they took in the Spring semester of the 2021-2022 academic year. Within the scope of the "Use of Technology in Mathematics Education" course of in-service primary school teachers taking postgraduate education and "Mathematics Teaching" course of pre-service primary school teachers, the instructor of the courses provided training on the theoretical framework of the 5E learning cycle and digital worksheet design in GeoGebra. Participants were asked to create a new account on GeoGebra and design a worksheet with the existing interactive elements offered by GeoGebra in accordance with the 5E learning cycle model from www.geogebra.org/worksheet/new. These interactive elements include texts, existing GeoGebra materials, notes, questions, videos, images, pdf files, and web pages. The participants submitted their digital worksheet designs to the instructor as the performance task of the course. Then, in-service and pre-service primary school teachers who prepared the digital worksheets and gained experience in their application were contacted at the end of the semester in order to seek their opinions about these worksheets prepared based on the 5E learning cycle. Interviews were conducted with six in-service and six pre-service primary school who volunteered to participate in the study and be interviewed. The interviewed in-service teachers were coded as IST1, IST2 and so on, and the pre-service teachers were coded as PST7, PST8 and so on. In addition, 10 digital worksheets the participants developed were used as documents in the study. These documents were coded as DWS1, DWS2 and so on. Demographic information regarding the in-service and pre-service primary school teachers is presented in Table 1.

Table 1. Demographic Information regarding the In-service and Pre-service Primary School Teachers

Primary School Teachers

Participants	Gender	Year of seniority	Level of the class they teach	Technological equipment in their classrooms	School district
IST1	M	21	2nd grade	Computer, projector	Inner-city (disadvantaged area)
IST2	F	21	1st grade	Computer, projector	Inner-city
IST3	F	13	1st grade	Computer, projector	Inner-city
IST4	F	23	2nd grade	Computer, projector	Inner-city
IST5	F	5	Multigrade school (1-2)	Not available	Village school
IST6	F	13	2nd grade	Smartboard, projector	Village school

Pre-Service Teachers

Participants	Gender	Age
PST7	F	22
PST8	F	20
PST9	F	35
PST10	F	21
PST11	F	22
PST12	F	23

Data Collection and Analysis

For data triangulation, both interview and document analysis techniques were used in the study. The interview, the main data collection technique of research in the interpretivist tradition and used in qualitative research, can offer the opportunity to obtain information about the invisible phenomenon and to provide alternative explanations about the visible phenomenon (Glesne, 2020). Document analysis is a data collection and analysis technique based on the collection and analysis of written (books, journals, edicts, memoirs, declarations, articles, letters, graffiti, etc.) and visual (films, slides, videos, pictures, monuments, etc.) materials (Glesne, 2020; Sönmez & Alacapınar, 2019). To collect data, this study made use of semi-structured interview forms and 10 5E-DWSs the participants prepared as documents. These digital worksheets were included in the study following the approval of the participants. Two participants did not give permission for using their worksheets and hence their worksheets were not used in the study. Interviews with participants were conducted one-on-one and face-to-face. Although face-to-face interviews, a popular approach in educational research, is one of the most time-consuming and costly approaches (Creswell, 2020), face-to-face interviews were preferred to obtain more in-depth information. These interviews were conducted in line with the interview questions developed after reviewing the relevant literature and determining the research questions. Samples of seven research questions include: *"What do you think about preparing 5E-DWS? Do you think 5E-DWS is an effective and useful teaching material? Can you explain the reasons?", "What do you think about the advantages and disadvantages of 5E-DWS for teaching mathematics in primary school?"* or *"Can you compare 5E-DWS with pen-and-paper worksheets?"* Taking the participants' consent and the research ethics committee approval, the interviews were recorded. Interview durations ranged from 15 minutes to 40 minutes. The interviews were transcribed on the computer.

The data obtained from the interviews and documents were analyzed using inductive (content) analysis. The main purpose of inductive analysis is to reach concepts and relationships that can explain the data collected. To this end, the data obtained are first conceptualized by subjecting them to deep processing, and then the themes and patterns explaining the data should be identified by organizing them in a logical way according to the emerging concepts (Yıldırım & Şimşek, 2021). In the inductive analysis stage, each data is transcribed and read in detail, the written records are coded, and the findings are reported by reaching meaningful themes from the codes. The data obtained in this study were transcribed on the computer by the researchers and codes were created. For instance, the participants' views on 5E-DWS were examined, and codes such as "fits digital era", "easy", "active student" were created. Then, themes were determined based on the common points of the codes. At every stage of the data analysis process, codes, sub-themes from codes and themes from sub-themes were reached through following this path. The same analysis processes were followed in the analysis of the 10 5E-DWSs used as documents. The 5E-DWSs designed by the participants were categorized by coding them in line with the phases of 5E learning cycle. In order to analyze these stages reliably, multiple researchers code the data separately, and each of the resulting analyses is reviewed together (Miles & Huberman, 2019). Accordingly, in the data analysis process in this study, two researchers created codes by reading the written records obtained from the interviews in depth and examining the contents in the 5E-DWSs. Then, the two researchers came together frequently to ensure consensus between the codes, and completed the process of code generation, thematization and conceptualization. In this process, the reliability value was approximately 86% according to the formula *(consensus / agreement + disagreement X 100),* where agreements with a value above 70% are considered reliable, as suggested by Miles and Huberman (2019).

Validity and Reliability

In order to ensure construct validity in case studies, researcher triangulation, method triangulation and data source (participant) triangulation increase the credibility, accuracy and reliability of the research (Akar, 2016). Accordingly, in the current study, data sources were diversified by creating two different participant groups as in-service and pre-service primary school teachers. Data source triangulation requires including participants with different characteristics in the research (Yıldırım & Şimşek, 2021). In addition, two different data collection methods, namely interview and document analysis, were used to ensure method triangulation. In the case study design, using more than one data collection method generally allows for a rich variety of data that can confirm each other (Akar, 2016; Yıldırım & Şimşek, 2021). The comments of the participants in the data obtained in the interviews were analyzed by associating them with the contents of the digital worksheets, and the consistency between the data was sought to ensure. The interview forms were reviewed by three different experts (two experts in mathematics education and one expert in qualitative research methods) to ensure the credibility of the study. In addition, consensus among coders is important in data analysis to ensure reliability in qualitative studies. In qualitative research, reliability generally refers to the consistence of data across multiple coders' responses (Creswell, 2021). To this end, in this study, the two researchers came together frequently in the analysis of qualitative findings, coding and thematization of the data and conceptualization of these themes until a unity of concept was achieved. An expert examined the themes and codes generated from the data obtained from the interviews and document, and the data were revised in line with the feedback of this expert. For the internal and external validity of the research, the sample was diversified purposefully, and the research process, model, selection of participants, data collection and analysis were explained in detail. Direct quotations from participant opinions were presented by checking whether the findings and results reflect the reality (Yıldırım & Şimşek, 2021).

Findings

The findings regarding the data analyzed in line with the participants' opinions are systematized and presented in this section in connection with the research questions. The findings obtained as a result of the analysis were classified under seven themes. These themes include 5E learning cycle supported digital worksheets, the learning domains of the 5E learning cycle supported digital worksheets, advantages and disadvantages, comparison of pen-and-paper worksheets and digital worksheets, phases of the 5E learning cycle in the preparation process, experiences of practice in the learning environment, contents of the 5E learning cycle supported digital worksheets.

5E Learning Cycle Supported Digital Worksheets

The themes, sub-themes and codes obtained from data regarding 5E-DWS are presented in Figure 1 and Table 2.

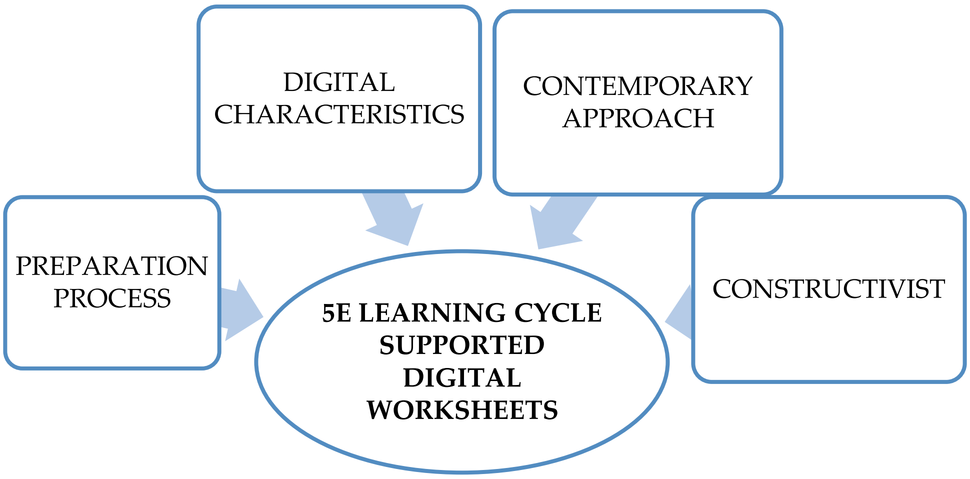

Figure 1. Themes and Sub-themes of 5E Learning Cycle Supported Digital Worksheets

Table 2. In-service and pre-service teachers' opinions on the 5E learning cycle supported worksheets prepared with GeoGebra

5E Learning Cycle Supported Digital Worksheets		
Sub-themes	**Codes**	**Participants**
Preparation process	Easy	IST3
	Complicated	IST1, IST2, IST3, IST4, IST5, PST11, PST12
Digital characteristics	Dynamic	IST1, IST2, IST3, IST6, PST8, PST10, PST11
	Sustainable	IST2, IST3, IST4, IST5, PST8, PST10
	Avoiding traditionality	IST3, IST4, IST5, IST6, PST7, PST8, PST10, PST12
Contemporary approach	Fits digital era	IST2, IST4, IST6, PST10, PST12
	Unconventional	IST1, IST4, PST7, PST10
	Versatile	IST2, IST3, IST6, PST7, PST10
	Active student	IST1, IST2, IST3, IST4, IST5, IST6, PST9, PST10, PST12
Constructivist	Interactive	IST1, IST2, PST8, PST12
	Association with daily life	PST8
	Cognitive construction	IST1, PST10
	Learning by doing-experiencing	IST6, PST12

a. *Preparation Process*

This sub-theme reflects the participants' opinions regarding their experiences in the preparation process of 5E-DWS. As presented in Table 2, the majority of the participants reported that the preparation process for 5E-DWSs with GeoGebra was challenging and they had difficulty during this process, and they emphasized its *complicated* nature. On the other hand, an in-service teacher stated that 5E-DWS was complicated and challenging; however, described digital worksheet preparation process as *easy* after learning how to use the GeoGebra software. IST3 stated: *"When we understand the preparation part, it is actually very easy. At first, I didn't understand it at all, it seemed utopian to me, but when we examined the worksheets, (...) I became involved in the process, just as the student is involved in the process (...)"* and underlined that the process got easier as they learned the program. IST2, stating that it was complicated and challenging, said s/he did not understand it at first, and s/he never studied 5E learning cycle beforehand, so it was complicated for her/him. IST2 said: *"(...) I worked on it for days. Because I didn't know it at all, maybe that's why I had a lot of difficulty, and I renewed the GeoGebra page I prepared many times. I mean, I was able to realize my shortcomings every time I did it. For example, I didn't do it according to the 5E model at first, I mixed it up."* The participants stated that, in the preparation process of 5E-DWSs, they struggled for days, they searched it themselves, sought help from the instructor, and hence tried to make sense of the complicated software.

b. *Digital Characteristics*

This sub-theme reflects the participants' emphasis on the digital characteristics of the 5E-DWS. The participants underlined characteristics of 5E-DWS such as being movable and renewable. These features point to the digital characteristics of the worksheets. Most of the participants stressed the dynamic features of the digital worksheets they prepared. They stated that the movability and using sliders features in 5E-DWS was different from traditional worksheets and attracted students' attention (IST1, PST9) and that it supported students' learning on their own by giving the control to the students (PST10). IST6 stated that these characteristics made students active; IST1 stated that the students liked working with 5E-DWS because it allowed them to see the three-dimensional subjects of mathematics by moving them. PST11 argued that movability feature enabled permanent and fast learning. Participants expressed that the dynamic nature of the digital worksheets enabled teachers to concretize abstract subjects that were difficult to explain, and that students' being able to move the sliders on their own enabled them to better perceive the subjects. A pre-service teacher explained this as following: *"Honestly, it is very nice. Children can see it concretely, can move it. I think it opens their horizons a lot. (...) We can play it, we can see it, we can see how it closes and opens when it is closed and open, when the numbers get bigger and smaller (...)"* (PST8). Another participant thought that the dynamic features of 5E-DWS allow students to explore themselves and said: *"The child sees it. It is one thing for the child to think about it, another to see it, and another to discover it oneself by moving it. The child learns by oneself."* Some of the participants stressed that digital worksheets provided students with the chance to review. Emphasizing the dynamic features, IST6 told that this software could be used not only in the classroom environment but also in online synchronous lessons. IST6 said: *"We need to be innovative. We will use distance education a lot more due to such diseases and things. It is a perfect thing especially for distance education. It can be done directly in the classroom in a live online lesson with students."* Some of the participants mentioned about the sustainability of 5E-DWS. On this *sustainability* code, the participants stated: *"(...) we actually offer an environment where the child can draw both visually and by himself, then watch the video and then review the subject."* (IST3) and *"(...) I think that the child can re-enter from the same link and say, 'this is how it works' again and remember it immediately."* (PST10). With this *sustainable* code, it is emphasized that 5E-DWS offers an environment where students can review the subjects.

c. *Contemporary Approach*

This sub-theme reflects the participants' views that 5E-DWS is an innovative and contemporary learning tool that is far from traditional approaches and offers digital-friendly and versatile learning environments. The participants mentioned that the application was innovative (IST3, IST6), nonmonotonic (IST2), appropriate for children born in the digital age and it reduced the challenges of traditional methods (PST10, PST12) and offered different learning environments (PST7). The participants stated that, thanks to the 5E-DWS, they could get away from traditional teaching approaches, put forth an approach fitting the digital era, and construct an unordinary and versatile learning environment. A pre-service teacher who found the digital worksheets very beneficial explained the phases of the learning model as: *"Because the introduction is all about drawing attention, exploration is completely left to the children, explanation is a step taken by the teacher to correct mistakes, elaboration is an additional step, evaluation in the sense of control"* (PST10) and mentioned that this method could construct a better and efficient learning environment since the teacher has the control and students are freed from pages of homework. A teacher emphasized that this was a needed model. A teacher who prepared a digital worksheet for subtracting by breaking apart tens and ones mentioned the negativities in the teaching models in his childhood and expressed the positive aspects of this teaching model compared to traditional approaches as follows: *"You can visually explain many things that are imposed by rote memorization in children's minds, such as why we have tens, why we take tens in subtraction"* (IST4). In addition, the same teacher reported that an unordinary teaching could be possible with these digital worksheets with the following words: *"I mean, both in terms of attracting their attention and in terms of digitality... sometimes I say 'if we upload this as a game, if it is called a game', children will play it as a game, some works are really successful in this sense"* (IST4). Some participants stated that this teaching material fitted to the digital age and hence it was effective for new generation students, and it appealed to the students therefore, and additionally, teachers could monitor students' progress in the digital environment. IST6 said: *"First of all, the fact that it is digital is a plus. Because everyone likes screens. The students we teach are the ones who have phones in their hands all the time. Therefore, they will be able to study with the phone in their hands. (...) the fact that the teacher can see it at any time is also a plus"*, and PST12 said: *"We are in the digital age. Working with digital worksheets can be more fun for children and make the lesson more productive."* Participants expressed opinions that digital worksheets supported by the 5E learning model offer multidimensional learning environments and prevent the child from progressing monotonously. Regarding digital worksheets, one of the teachers stated: *"the child is visual, it can appeal to many areas that we call multiple intelligence"* (IST2).

d. Constructivist

This sub-theme points to statements associated with the characteristics of 5E-DWS reflecting constructivist learning approach. To explain in more detail, it is seen that the features of 5E-DWS such as interactive and active learning, associating with daily life, learning by doing and experiencing, and constructing in the mind reflect the constructivist learning approach. They expressed that students' being active enabled them to explore subjects (IST1, PST10, PST12), observe themselves and learn (IST6, PST8). They argued that 5E-DWS is a tool that helps students construct concepts in their minds and learn subjects by doing and experiencing. In-service and pre-service primary school teachers elucidated that 5E-DWSs used in classrooms activate students, increase interaction, allow for association with daily life and learning by doing and experiencing, and hence students construct knowledge in their minds, so it is appropriate for constructivist approach. Some of the participants, for instance, explained the phases of 5E learning cycle and stressed the positive aspects of this teaching material. For the *engage* phase, PST9 said: *"The student will not even realize it because the student himself will be involved in it. The student's attention will be drawn beforehand, he/she will be motivated and will progress to the next level with excitement."*; for the *explore* phase, IST4 said: *"At the stage of making inferences, while making some inferences, the student already understands the subject, 'huh what is it?' 'It was like this when it was like this' (...) you know, by drawing attention and making inferences, it actually allows for a student-centered education system"*; for the *explain* phase, IST1 said: *"(...) then you explain it. The child says 'OK!', 'what I said, what I understood is right' or 'wrong'. As a result, it settles in the mind."*; for the *elaborate* phase, PST12 said: *"in elaboration phase, the child himself is active"*; and finally, for *evaluate* phase, IST2 expressed that evaluation phase was very nice and enjoyable and emphasized that student are active also in this phase by saying: *"I added three clocks here. (...) I wanted the children to show the clocks themselves by drawing hour and minute hands. Children will not only choose their own colors and create their own minute hands but also pay attention."* Emphasizing that it is a teaching material in which students have the opportunity to learn by doing and experiencing in a digital environment, IST6 stated, *"(...) the student can see it one-to-one, you know, we say learning by* *experiencing, maybe they do not experience it, but they really observe it one-to-one and discover it because they find it by moving it themselves."* PST8 stated that the 5E learning model allows the student to associate with daily life and that it is a student-centered teaching material.

The Learning Domains of 5E Learning Cycle Supported Worksheets

The themes, sub-themes and codes generated from the data obtained from the learning domains in which the 5E learning cycle supported digital worksheets were prepared are presented in Figure 2 and Table 3.

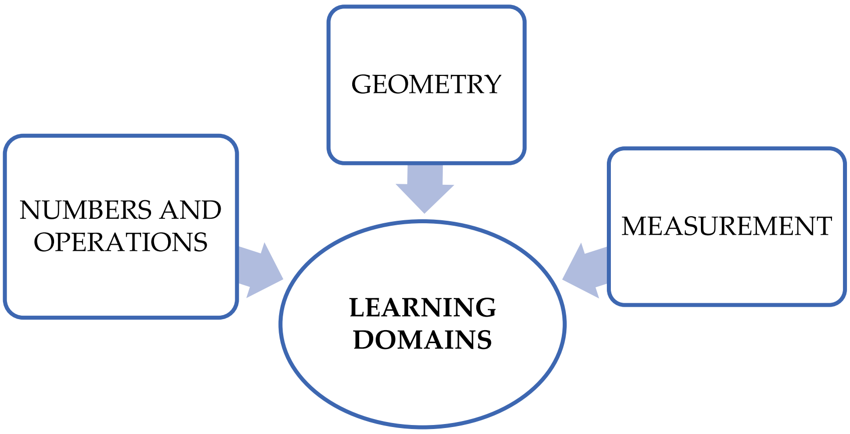

Figure 2. The learning domains of 5E learning cycle supported worksheets

Table 3. The learning domains of 5E learning cycle supported worksheets

Learning Domains			
Sub-themes		**Codes**	**Participants**
Learning domain	**Learning sub-domain**	**Subjects**	
Numbers and Operations	Natural Numbers	Rounding to tens	IST3
		Place value	IST4, PST9, PST11
	Subtraction in Natural Numbers	Multi-digit subtraction	IST4
	Multiplication in Natural Numbers	Multiplication	IST6
		Associative property of multiplication	PST7
		Multiplicative comparison meaning	PST8, PST10
	Division in Natural Numbers	Finding the missing value	PST12
	Fractions	Whole, half and quarter	IST2
Geometry	Geometric Objects and Shapes	Solid objects	IST5
	Spatial Relationships	Symmetry	IST1
Measurement	Measuring Time	Clocks	IST2

This theme refers to the participants' preferences regarding the learning domains and topics in the primary school mathematics curriculum in the process of preparing 5E-DWSs. It was observed that the learning domains and subjects the in-service primary school teachers preferred were generally determined according to the curriculum at the grade level in which they taught. The pre-service primary school teachers stated that they chose the subjects that they thought they could prepare worksheets more easily through the software. The participants mostly preferred subjects in the "Numbers and Operations" learning domain. The digital worksheets the participants were related to the subjects of natural numbers, subtraction in natural numbers, multiplication in natural numbers, division in natural numbers, fractions in the numbers and operations learning domain; geometric objects and shapes, spatial relations in the geometry learning domain; and measuring time in the measurement learning domain. In line with the opinions, learning domain and learning sub-domains were categorized as sub-themes and subjects were categorized as codes. The learning domains in "Mathematics Curriculum" in Turkey for the first and fourth graders include numbers and operations, geometry, measurement and data processing (MoNE, 2018). The data obtained from the participants' opinions regarding the 5E-DWSs they prepared showed that they did not prepare any worksheets in sub-domains of addition in natural numbers and operations with fractions in numbers and operations domain; sub-domains of geometric patterns and basic concepts in geometry in geometry learning domain; sub-domains of measuring length, measuring perimeter, measuring area, money, weighting and measuring liquid in the measurement learning domain; and none of the sub-domains of data processing learning domain (it has the sub-domains of data collection and evaluation)

a. Numbers and operations

The participants mostly preferred the "Numbers and Operations" learning domain. The sub-domain of place value in this learning domain was preferred at a greater degree (IST4, PST9, PST11). IST3 prepared a digital worksheet in the rounding to the nearest ten subject of this learning sub-domain and said: *"(...) for example, when I explain rounding to the nearest ten in the classroom, I say 'if the number is less than 5, the ones digit stays in its own tenth, if it is 5 or more than 5, it is rounded to the neearest ten', we solve examples. Do they learn? Yes, they learn. I give them lots of photocopies, but here's the thing."* IST3 added that s/he could not reach to some students and mentioned negative aspects of by expressing s/he could not ensure permanent learning. IST4 prepared a digital worksheet on place value and stated: *"Ones, tens, hundreds (...) In the second grade, you know there are tens and ones, but not hundreds. In this way, I also taught them the hundreds, I instructed them beforehand"* (at this time the participant was in high spirits, his/her tone of voice became excited) and added that the students could easily learn the subject with the digital worksheets. The participants prepared 5E-DWSs in the subjects of multi-digit subtraction in the subtraction in natural numbers learning sub-domain (IST4); multiplication (IST6), associative property of multiplication (PST7), multiplicative comparison meaning (PST8, PST10) in the multiplication in natural numbers learning sub-domain. PST10, attending internship in a study center, prepared a digital worksheet on multiplicative comparison meaning and expressed that the subject was difficult, and s/he selected this subject because it was needed. PST10 said: *"(...) it was difficult to explain multiplication to the children in the study center. For example, when I divide 52 by 2, you first ask the child, is there 2 in 5? That comes easily to him/her (...) But when I say divide 18 by 9, s/he is stunned, s/he does not know what to do."* PST12 prepared a digital worksheet on finding the missing value subject in the division in natural numbers learning subdomain. S/he explained this preference by saying: *"I prepared it in the equation subject. It is a fourth-grade learning outcome. I thought we could use a scale. (…) I thought we could use the slider in the left and right hand side of equation."* IST2, on the other hand, stated that fractions and hours topics were visually richer and prepared digital worksheets on these topics.

b. Geometry

Two participants prepared 5E-DWSs in the geometric objects and shapes and spatial relationships sub-domains of geometry learning domain in the mathematics curriculum. IST5 prepared a digital worksheet on solid objects, a subject of geometric objects and shapes, and expressed a need for this subject and selected solid objects subject considering the sequence in the curriculum. IST5 said: *"In the second grade, the subject of solid objects is covered. Since there was no problem in terms of addition and subtraction, when we went according to the annual plan, that was my next subject."* IST1 explained the reason for selecting the symmetry subject as: *"Now, visually, this child needs to see. (...) Of course, showing with pictures has its good sides. But here the child moves, sees and understands for himself/herself. This helps the child to understand."*

c. Measurement

An in-service teacher prepared a worksheet in the subject of clocks in the measuring time sub-domain of the measurement learning domain. IST2 stated that her/his grade level was actually first grade, but s/he prepared a digital worksheet on the subject of Clocks, which is a second-grade outcome, to make it different. In this regard, IST2 said: *"Clocks, that is, I mean, I was interested in it myself. For example, the movement of the hour hand, the minute hand, the continuation of the slider, etc. That's why I selected this subject."*

Advantages and Disadvantages

The themes, sub-themes and codes generated from the data regarding the advantages of the 5E learning cycle supported digital worksheets are presented in Figure 3 and Table 4.

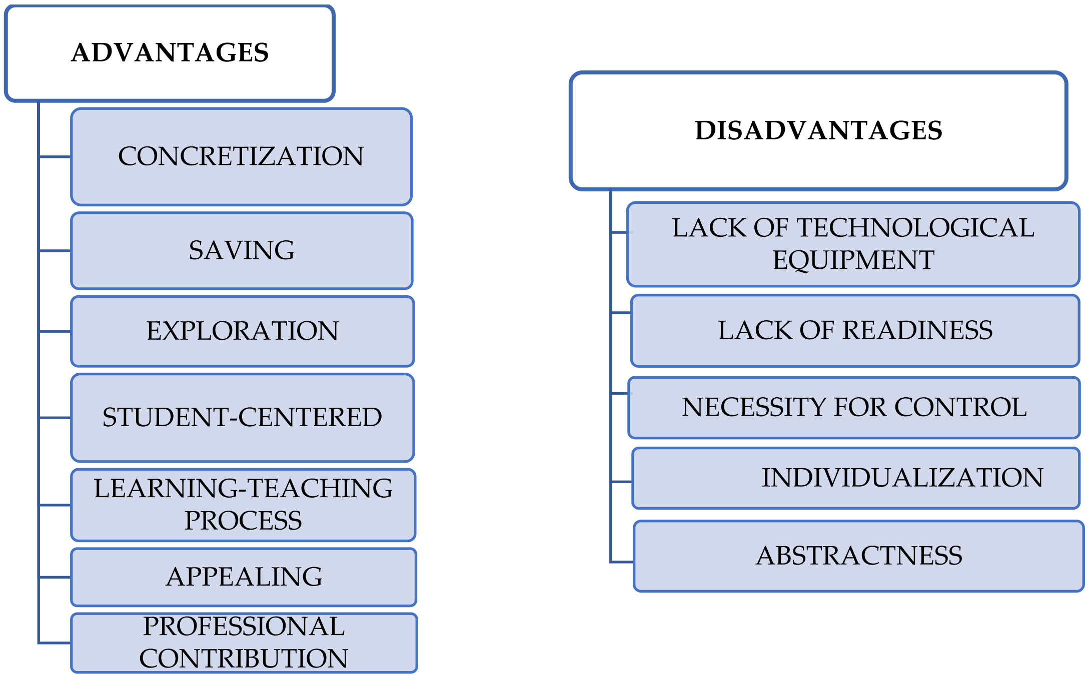

Figure 3. Advantages and disadvantages of 5E learning cycle supported digital worksheets

Figure 3 presents the sub-themes regarding the advantages and disadvantages of 5E-DWS together. In the following part, the findings regarding the advantages and disadvantages of 5E-DWS are addressed in separate headings.

Advantages

The opinions regarding the advantages of 5E-DWS for teachers and students were analyzed and presented here.

Table 4. Advantages of 5E learning cycle supported digital worksheets

Advantages		
Sub-themes	**Codes**	**Participants**
Concretization	Modelling mathematics	PST10
	Visuality	IST1, IST2, IST3, IST4, IST6, PST9, PST10, PST12
	Three dimensionality	IST4, IST6, PST8, PST9, PST10
Saving	Saving paper	IST3, PST8, PST10, PST11
	Saving time	IST4, PST10, PST11
Exploration	Constructing in mind	IST1, IST4, PST10
	Inference	IST2, IST4, IST6, PST8, PST10, PST11
	Comparison	IST1
Student-centered	Active learning	IST1, IST2, IST3, IST4, IST5, IST6, PST7, PST8, PST9, PST10, PST11, PST12
	Individual learning	IST1, IST2, IST4, IST6, PST7, PST8, PST9, PST10, PST11
	Inclusive	IST2, IST3, IST6
	By doing-experiencing	IST1, IST2, PST12
	Fits the digital generation	IST3, IST4, IST6, PST9, PST11, PST12
	Learning higher-level outcomes	IST4
Learning-teaching process	Feedback	IST1, IST5, PST9, PST10, PST11
	Controllable	IST3, IST4, IST5, IST6, PST10, PST12
	Gradual learning	IST2, IST3, PST7, PST9, PST10, PST12
	Removing misconceptions	IST5, PST10
	Permanent and effective learning	IST1, IST3, IST4, IST5, IST6, PST7, PST8, PST9, PST10, PST11, PST12
	Fun learning	IST1, IST2, IST4, IST5, PST7, PST8, PST12
	Fast learning	PST11
Appealing	Intriguing	IST1, IST2, IST3, IST4, IST6, PST7, PST9, PST10, PST12
	Motivation	IST1, IST3, PST7, PST9
Professional contribution	Refreshed teacher	IST2, IST3, IST6, PST7, PST8, PST11, PST12
	Versatile teacher	IST2, IST3, IST6, PST7, PST10
	Active teacher	IST2, IST3, PST8
	Flexible teacher	IST2, IST3, IST6, PST7, PST11, PST12

a. Concretization

This sub-theme refers that the features of 5E-DWS such as supporting subject with video, image and models and modelling mathematics concretizes mathematics which is an abstract lesson. The codes under the concretization sub-theme were modelling mathematics, visuality, and three dimensionality. In visuality, the participants (IST1, IST2, IST3, IST4, IST6, PST9, PST10, PST12) thought that the students could easily concretized the subjects more easily thanks to teaching materials such as video, image, and Dienes blocks (a material used in teaching place values in mathematics). Regarding visuality, IST4 emphasized the concretization feature of the digital worksheets prepared in GeoGebra by saying: *"When we are explaining geometric objects, we concretize things like syrup boxes and so on, but the folding and unfolding of the geometric objects there, which faces they have when they are opened, that is, the child sees it visually, (...) not through lecturing but the child sees it. The child codes that in his/her visual memory..."* Regarding modelling mathematics feature of digital worksheets, PST10, also working as a teacher, told that s/he used these worksheets in the study center. On this issue, PST10 said: *"I showed them that worksheet. '3 times 4 and 4 times 3 are the same', but when it comes to modeling, I tried to make them understand that '3 apples in 4 crates or 4 apples in 3 crates are different' and this was difficult in that classroom environment. So, I showed the digital worksheet. (...)"* In addition, the participants stated that the three-dimensional materials and dynamic features offered by GeoGebra made it easier for students to learn subjects that are difficult to construct in their minds in mathematics teaching (IST4, IST6, PST8, PST9, PST10). For example, thinking that 5E-DWS enables students to see things three dimensionally, PST9 expressed that s/he even had difficulty in three dimensional objects and s/he eventually got enlightened about some issues on three dimensionality thanks to the digital worksheets s/he prepared on GeoGebra. PST9 said: *"Questioning 'Which solid object has how many faces, what is it?', I grasped the idea. We have memorized it until now. (...) There are definitely children like me in three-dimensional subjects. They cannot think adequately. There are some children with imagination. I think they can learn by seeing it."*

b. Saving

This sub-theme reflects the participants' opinions regarding that 5E-DWS provides saving in terms of time and material. The saving sub-theme, based on the participants' opinions includes the codes of time saving (IST4, PST10, PST11) and paper saving (IST3, PST8, PST10, PST11). PST11 argued that the digital worksheets prevent wasting both time and paper. On this, PST11 said: *"(...) there is no waste of paper. You collect the paper worksheets; you look at what the student has done. You check them one by one. This is not very possible for the teacher. Especially if the classes are crowded. But with digital worksheets, you can look at them anywhere."*

c. Exploration

This sub-them is related to the notion that 5E-DWS enables students to explore the subjects and concepts on their own and make inferences. The exploration sub-theme consisting of the codes of constructing in mind, inference, and comparison, obtained from the participants' opinions, are presented in Table 4. The participants declared that 5E-DWS allowed students to make inferences and explore the subjects (IST2, IST4, IST6, PST8, PST10, PST11). Regarding the inference code, IST4 stated that the students themselves understood the subject and that as a teacher, they only guided the children by asking them questions, saying: *"I liked it they made inferences when I said them: 'what happened guys?' you know 'what happened when there was an increase here?', ' there was a decrease', (…)*The participants stated that thanks to the digital worksheets, students were able to structure the knowledge in their minds (IST1, IST4, PST10), make inferences, comprehend the topics better and they were able to make comparisons (IST1). IST1's statement regarding the constructing in the mind code in this context is as follows: *"(...) you make the child discover. S/he understands the material himself. The child says 'OK, this is like this'. S/he makes sense. S/he grasps its logic. Since s/he discovers it himself/herself, it's like..."* IST1 also stated that students were able to make comparisons thanks to the phase of the 5E learning cycle.

d. Student-centered

This sub-theme posits the participants' view that 5E-DWS supports students' comprehensive, active, individual, and learning by doing-experiencing, fits the digital generation, and addresses higher-level outcomes. The participants voiced that the digital worksheets are materials that centers in the students in the learning process. All the participants specified that this instruction material supports active learning. In addition to active learning, another issue which is strongly emphasized is that it provides opportunities for students' individual learning (IST1, IST2, IST4, IST6, PST7, PST8, PST9, PST10, PST11). Stressing that students should be active and learn individually, PST8 said: *"Students can also learn on their own. We only give hints. The child continues. The child then learns on his/her own, the child discovers on his/her own. The child deepens knowledge..."* PST8, PST9 and PST10, who stated that 5E-DWS supports students' active and individual learning especially in distance education process, said that students can learn on their own with this 5E-DWS. Regarding this issue, an example opinion belongs to PST8, who said: *"Assuming that it is provided in distance education, children can easily play and do this from where they are. I mean, they can discover it themselves."* Some of the participants (IST3, IST4, IST6, PST9, PST11, PST12) mentioned the relationship of the new generation of children with the digital world and stated that 5E-DWS would be interesting for students. Saying, *"(...) when we put technology to work… When we put digital worksheets to work… You know, the child is already playing with the phone. They have an interest in technology. We are actually using this interest."*, IST3 stated that using children's tendency towards technology and the digital age correctly will make children more successful.

The participants pointed out that 5E-DWS allows students to learn by experiencing and doing themselves (IST1, IST2, PST12). On this PST12 said: *"With the constructivist philosophy, it is expected that students should be more active, and a lesson plan should be prepared in which the teacher is not at the center but a guide. In this application, students can experiment and discover more. I think it is appropriate to use it because it is more student-centered."* Furthemore, (s)he added that thanks to 5E-DWS, students can learn by experiencing and doing, and participate in the lesson actively. One teacher (IST4) stated that when implementing digital worksheets in her/his classroom, s/he was able to teach the learning outcomes of the next grade level. On this IST4 provided this example: *"For example, because I entered 45 as a value, as a number on the program. For 45, it shows blocks of 5 ones and 4 tens. But while entering 45, we also entered 145 and 245. In terms of preliminary preparation... In fact, I don't think it is preliminary preparation, I think I have taught the hundreds that I should teach in the third grade."* In this example, the participant stated that while teaching tens and ones in accordance with the curriculum with the 5E-WS in the lesson, GeoGebra provided students with the opportunity to observe the process thanks to the continuous change of blocks according to the input. In this way, students were able to easily reach the objectives targeted in the upper grades.

e. Learning-teaching process

This sub-theme reflects the participants' opinions about the effects of 5E-DWS on the learning-teaching process. The participants stated that 5E-DWS would make learning permanent, effective, fast, and fun, provide progressive and individual learning, give the teacher feedback and instant control, allow the teacher to plan flexibly according to his/her class and eliminate students' misconceptions. The participants emphasized permanent and effective learning. In general, they asserted that the repetition opportunities provided by 5E-DWS, its attractiveness, allowing self-experience, providing concrete materials encourage permanent and effective learning (IST1, IST3, IST4, IST5, IST6, PST7, PST8, PST9, PST10, PST11, PST12). IST3 argued that even though students learn a mathematical subject taught via the traditional method, they do not learn it permanently, and laid emphasis on digital worksheets with these statements: *"But if I prepared such a digital sheet for the child, let's say I taught that topic in class for a week, and I gave it for homework while I was teaching another topic, and if he repeated it at home... (...) What will happen to the child this time? Learning will become permanent."* Another participant, PST11, stated that *"It can make learning more permanent and faster because it makes the student active"*.

Several participants thought that 5E-DWS made mathematics education fun (IST1, IST2, IST4, IST5, PST7, PST8, PST12). Regarding its effect on mathematics instruction in terms of efficiency and fun, IST5 said: *"It is effective and useful... At least it makes the lesson more fun. (...) I think it makes mathematics more fun with digital worksheets, at least we break students' prejudice."* IST3 argued that 5E-DWS was effective and told that the students had the chance for individual learning environment, by saying: *"(...) We offer an environment where the child can draw both visually and by himself, then watch the video, then repeat the subject. (...) we open up a new space for the child, we take the child to a new space."* PST7 stated that it offered an environment that would enable students to learn on their own. PST7 stated that the instructor expressed about the 5E-DWS, , *"You will send this to the children, and you don't need to say anything, the child will read the instructions and do it accordingly and said that this idea excited him very much.."* The participants were of the opinion that students could learn contents gradually thanks to 5E learning cycle (IST2, IST3, PST7, PST9, PST10, PST12). PST10 explained that 5E-DWS enabled gradual learning with these statements: *"(...) I find it very useful because the engagement is important for drawing attention, and exploration are completely left to the children, explanation is a step taken by the teacher to correct mistakes, elaboration is an additional step on explanation, and finally evaluation in terms of control."*

The participants conceived that, thanks to 5E-DWS, they could easily control students (IST3, IST4, IST5, IST6, PST10, PST12) and get feedback from them (IST1, IST5, PST9, PST10, PST11). IST3, who stated that 5E-DWS provides an opportunity for teachers to control students, said: *"I guide the child to what I want to teach or to the outcomes I have prepared within the scope of the objectives of the program. The child is not on his/her own. In fact, the child is under my supervision without me."* Regarding the control and feedback features of 5E-DWS, IST5 said: *"Since we give directly feedback in the digital working environment, it can be more advantageous. It makes it easier for both the student and the teacher in terms of feedback."* and added that it fixes the learning errors, and it is an appropriate teaching material for removing students' misconceptions. Similarly, on removing misconceptions, PST10 said: *"4 times 3 and 3 times 4 are not the same when we change them. (...) This is actually a misconception."* The same pre-service teacher added that since this misconception in multiplication would cause misconceptions in other related subjects, this could also be prevented.

Stressing that students are also active in this process, IST6 said: *"You know how it is said that 'a program will be prepared and taught according to his/her own needs of each student', this never happens. But you can put as many examples as you want in it, it is unlimited. You can provide examples for every student."* and argued that 5E-DWS meets the needs of the whole class and offers a learning environment covering all students. In the same vein, regarding comprehensiveness, IST2 told: *"The good thing here is that, with the 5E model, it does not only motivate successful students, but also unsuccessful students, at least, for example, you have prepared a question with ten steps, even getting to three of them is a success for them. It ensures that those children are not ignored."*

f. Appealing

This sub-theme reflects the participants' opinions regarding the feature of 5E-DWS that attract students' attention. That 5E-DWS can be supported with videos, images, games, questions and so on allows students to progress easily by grabbing their attention. Majority of the participants thought that 5E-DWS attracts students' attention and arouse curiosity (IST1, IST2, IST3, IST4, IST6, PST7, PST9, PST10, PST12). Besides, they were of the opinion that it improves students' motivation and hence motivate them for learning (IST1, IST3, PST7, PST9). For example, IST1 told that 5E-DWS aroused curiosity in students and motivated them, and added: *"(...) in providing motivation, you first make the child curious. (...) When we ask an interesting question, children's interest increases. They say 'I wonder what it is'."* PST9, talked about the gradual nature of the 5E learning cycle and remarked: *"First, we should grab students' attention, the students will be motivated and move on the next phase excitedly. (…) If done in accordance with grade levels, this will arouse students' curiosity and they will struggle themselves to pass on the next phase."*

g. Professional contribution

This sub-theme posits the participants' opinions regarding the contribution of the 5E-DWS on teachers' professional development. Regarding the advantages of digital worksheets, the participants reported that it enables professional development, provides teachers with different perspectives, allows teachers to think in multiple ways by focusing on different areas, and makes teachers active. The participants thought that it helps teachers refresh themselves continuously (IST2, IST3, IST6, PST7, PST8, PST11, PST12), develop themselves in terms of digital technology and leads them to contemporary approaches. A pre-service teacher (PST7) voiced that children are bored of traditional instruction methods and added: *"That's why we, pre-service teachers, are in search of different things, we focus on things that can attract their interest, like games. So, these worksheets are out of the ordinary, I think students will like them."* Another pre-service teacher (PST8) mentioned that 5E-DWS makes teachers more active and said: *"We didn't practice this in our own primary school, but that's how we are trying to train ourselves. That's why we grow from scratch as teachers. We are after how much more effective we can be."* IST stated that he was also very active in the process of preparing the digital worksheets. IST2 said: *"(...) I worked on the clock myself for days on the minute hand, the hour hand, the rotation speed, the direction, etc. (...) I renewed the GeoGebra page I prepared many times. So, I was able to realize my inadequacy every time I did it."* In accordance with the flexible teacher code, the participants (IST2, IST3, IST6, PST7, PST11, PST12) stated that they could determine the subjects and the course of the subjects according to the levels of their classes and that they could organize them according to their classes without using ready-made materials thanks to digital worksheets. On this, PST12 mentioned that teachers had the chance to be flexible according to the class, with these remarks: *"(...) I can see more clearly what appears in the child's mind, at which stages they get stuck. Therefore, when I explain to the child, I make explanations for him/her. For example, if it is a three-step thing, if the child discovered the first step, moved on to the second step and then to the third step, I do not emphasize the first step too much in the explanation."* IST2 said: *"It is in the hands of the classroom teacher to know which subject to use and where to use it. As such, each teacher can change the usage area of each GeoGebra according to his/her place and class level (...)"* and so told that digital worksheets provide teachers' flexibility to change the learning environment in accordance with their class.

In the versatile teacher code, the participants (IST2, IST3, IST6, PST7, PST10) told that they can create a learning environment where they can tend to different areas. PST10 argued that they could turn to different areas and cultivate themselves with these remarks: *"Personally, I only had an experience in mathematics, but while I was researching mathematics, I also discovered different game sites related to my field, whether in science lessons or Turkish lessons. Especially in science (...) there was a site that I first discovered. I moved it there. I adapted that to a worksheet there."*

Disadvantages

The findings regarding the disadvantages of 5E learning cycle supported digital worksheets are presented in Table 5.

Table 5. The disadvantages of 5E learning cycle supported digital worksheets

Disadvantages		
Sub-themes	**Codes**	**Participants**
Lack of technological equipment	Student-related	IST2, IST4, IST5, PST7, PST11
	School-related	IST4, IST5, PST7
Lack of readiness	Inexperience in technology	IST1, IST2, IST5, IST6, PST7
	Inadequacy in reading/understanding/comprehension	IST1, IST2, IST5, PST9, PST11
	Teacher's lack of software knowledge	PST7
Necessity for control	Uncontrolled use of technology	IST4, PST10, PST12
	Family indifference	IST5
	Student's need for support	IST1, IST2, IST6, PST7, PST10, PST11, PST12
Individualization	Inhibiting peer interaction	PST10, PST11
	Lack of face-to-face contact with teacher	IST3, PST10, PST11
Abstractness	Non-touching	PST8

The participants' opinions about the disadvantages of digital worksheets were categorized into the sub-themes of lack of technological equipment, lack of readiness, necessity for control, individualization, and abstractness. The participants mostly reported that they had troubles in the cases when they could not control the learning environments practiced with 5E-DWS. Detailed information for the sub-themes is provided below.

a. Lack of technological equipment

This sub-theme accommodates the participants' opinions regarding the deficiencies in technological equipment stemming from students and schools while using 5E-DWS. The participants expressed that it is very hard to use 5E-DWS in lack of technological equipment cases stemming particularly from students (IST2, IST4, IST5, PST7, PST11). Besides, some participants stated that 5E-DWS cannot be used effectively in cases when there is lack or deficiency of technological equipment in the schools (IST4, IST5, PST7). PST7 told that there may be lack of technological equipment that are both student and school related.. S/he supported this by saying: *"(...) whether the schools have computers, i.e., technological infrastructure, can be a bit of a disadvantage, teachers not being well-equipped can be a bit of a disadvantage. It may be a disadvantage that students are not yet very interested in technology in village schools."*

b. Lack of readiness

This sub-theme reflects the participants' views that inadequate knowledge and experience of teachers and students may cause difficulties in the use of 5E-DWS. Regarding the disadvantages of 5E-DWS, the participants stated that they experienced or could experience various difficulties in the use of this teaching material due to technological inexperience (IST1, IST2, IST5, IST6, PST7). In line with the code of inexperience in technology, IST2 said: *"For example, I have this problem mostly with my children in the village. Children lacking experience technology sometimes have difficulty in knowing where to click and how to proceed. (...)"* and stated that this could be improved. There were also opinions that problems arising from students' inadequacies in reading comprehension could be a disadvantage (IST1, IST2, IST5, PST9, PST11). IST1, who also stated that students do not have a good command of technology, expressed the following views on this issue: *"The child will read but may not understand. Wouldn't it be better if there was something with sound?" For example, if the child who doesn't understand what he/she reads is left alone, for example at home, can he/she get through it?"* In addition, PST7 reported that teachers' insufficient knowledge of GeoGebra software could also be a disadvantage.

c. Necessity for control

This sub-theme reflects the views expressing the difficulties related to the control of students in the use of 5E-DWS in the learning-teaching process. Participants reported that students needed support with digital worksheets and GeoGebra, especially in the first stage (IST1, IST2, IST6, PST7, PST10, PST11, PST12). PST11 stated that some students may have difficulties due to their lack of readiness as follows: *"I think these stages are introduction, development, for example. If they are unaware of the previous subjects, I think they will have a little bit of difficulty. I mean, if their prior knowledge, their readiness is a little bit lacking, they may have difficulty (...)"* This pre-service teacher stated that students need support.

Some of the participants (IST4, PST10, PST12) stated that 5E-DWS should be controlled by parents and teachers in the learning-teaching process and that sometimes students have the opportunity to use the technology without control. IST4, who said that this could be a disadvantage, described his/her dialog with a student's parent as follows: *"I only heard this from a parent. (...) The use of computers and tablets is very high, especially during the pandemic period. 'He takes the tablet saying that he is going to do the worksheets, but he switches to other things and plays games.' Okay, of course, no matter how enjoyable the worksheet is, games are more enjoyable for children, unfortunately."* Emphasizing the difficulty for the teacher to integrate the digital worksheet into the lessons when the family is not interested, IST5 said, "*They all actually have phones or tablets. But they don't use it because the family's perspective on education is different."* IST5 added that they had active social media, but their parents made excuses about not being able to access the internet for a course-related issue.

d. Individualization

This sub-theme reflects the participants' views that 5E-DWS leads students to work individually and to learn away from collaboration. Participants noted that 5E-ESL individualizes students and reduces their contact with their teachers (IST3, PST10, PST11) and friends (PST10, PST11). PST11 stated that it prevents both peer learning and communication with the teacher as follows*: "(...) In the material given in the classroom environment, students can get help from their friends and teacher. But I think it will be difficult there because it is one-on-one, and students will do everything themselves."* IST3 addressed the disadvantage arising from the reduced interaction between the students and the teacher. S/he remarked: *"The child wants to see his/her teacher very much. S/he likes to make eye contact with the teacher. For example, for me, I also like to make eye contact. (...) I like this very much. Because I feel the person in front of me. (...) The child may also want to see the teacher, which can be a disadvantage."*

e. Abstractness

This sub-theme reflects the participant's view that 5E-ESL is abstract in nature. Only one of the participants (PST8) stated that it may be a disadvantage because students cannot touch the digital worksheet in the virtual environment. PST8 said: *"Maybe it may not seem concrete to the child. (...) S/he may not be able to move to the next level because s/he does not see anything concrete. Maybe when it is supported with concrete materials and digital worksheets (...) I think it will be at a higher level when the students have materials in their hands."*

Comparison of pen-and-paper and digital worksheets

The findings related to in-service and pre-service primary school teachers' comparison of pen-and-paper worksheets and digital worksheets are presented in Table 6.

Table 6. Comparison of pen-and-paper and digital worksheets

Comparison of Pen-and-Paper and Digital Worksheets			
Pen-And-Paper Worksheet		**Digital Worksheet**	
Codes	**Participants**	**Codes**	**Participants**
Uneconomical	IST3, PST8, PST10	Economical	IST3, PST8, PST10, PST11
Single use	PST10	Sustainable	IST4, PST10
Boring	IST4, PST7	Fun	IST5, PST12
Worrisome	IST4	Intriguing	IST3, IST4, IST5, PST10, PST12
Restricting	IST1, IST2, IST6	Multidimensional	IST2, IST3, IST6, PST10
		Enabling to explore	IST4, IST6, PST10
		Interactive	IST1, IST2
		Instant control	IST6, PST10, PST11
		Gradual learning	IST2, IST4
Traditional instruction	IST1, IST6	Fits digital era	IST3, IST4, IST6, PST9, PST11, PST12
		Fits new generation	IST4, IST6, PST7, PST9, PST12
		Active student	IST2, IST3, IST4, PST10
Easy	PST11	Challenging for teachers	PST11
Concret/hands-on	IST4, IST5, PST8, PST9, PST11	Dynamic	IST1, IST2, IST4

This theme reflects the participants' opinions on the comparison of 5E-DWS and pen-and-paper worksheets. Participants pointed that pen-and-paper worksheets were not economical and wasted paper. On the contrary, the same participants (IST3, PST8, PST10) stated that digital worksheets are economical and provide financial and time convenience, especially for the teacher. IST3 mentioned that pen-and-paper worksheets are not affordable and that this situation can be an obstacle to enriching the materials offered to students. This teacher said: *"(...) Of course due to economic difficulties, when we make photocopies, we make them black and white. Of course, this does not satisfy the child's eyes. Also, I don't have the opportunity to present a video in photocopying, for example."* PST10, on the other hand, thought that digital worksheet facilitates the teacher in terms of time and said, *"The print-out, i.e., the A4 paper, is a waste, while digital is not. I mean, we don't compromise anything in digital. It is a waste of nature, ink and so on. Besides, there is the errand of printing them out, dividing them into numbers (...)"* and expressed that digital worksheets provide savings in many ways. The same participant (PST10) also mentioned the disposable nature of pen-and-paper worksheets and indicated that digital worksheets are sustainable and said: *"The child will use it and s/he does not have any mistakes but s/he may look back at it later. (…) When turned back, it is important for the student to explore and be able to find it. But this is not very possible in pen-and-paper worksheets. But in the digital, the student can go the same link (…) and say 'Oh, this is how it works.' So (s)he remembers it immediately."* Thus, the students have the chance to observe, explore and review materials in digital environments. While IST4 and PST7 felt that pen-and-paper worksheets are boring, PST12 emphasized that digital worksheets are fun for students. IST4 said: *"The pen-and-paper worksheet is more* *boring; they even feel like an open-ended exam. Their stomach and their head aches when they see the pen-and-paper worksheet (...)"* and accordingly stressed that pen-and-paper worksheets are boring and worrisome for students. The participants mostly emphasized the intriguing feature of 5E-DWS (IST3, IST4, IST5, PST10, PST12). Similarly, PST12 argued that digital worksheets intrigue students and said: *"We are in the digital age, technology is something that attracts children's attention. Working with a digital worksheet may be more fun for children. (...)"* and added that the lessons would be more effective with digital worksheets. IST5 also referred to the fun characteristics of digital worksheets and said: *"(...) when reckoned for the primary school level, it can be fun for the child, it can be intriguing."* PST10 similarly said: *"With digital worksheets, the child comes to class with more curiosity and the lesson would be more appealing (…)"*

IST1, IST2 and IST6 said that pen-and-paper worksheets are more restrictive than digital worksheets. These teachers stated that pen-and-paper worksheets have a structure that makes students passive and restrictive in the form of monotonous question and answer such as fill-in-the-blank, matching and marking. IST6 said: *"(...) pen-and-paper worksheets are only for questions and answers. But digital worksheets have it all. I mean, there is lecturing, there is discovery, there are questions, there is a game, it is all there. This, of course, is incomparable and I think it brings digital to a plus level."* and mentioned that the contents of digital worksheets are very rich and enable students to explore.

Contrary to the views that pen-and-paper worksheets restrict students and teachers, some participants posit that 5E-DWS has a versatile structure and allows the learning process to be supported by many different audio-visual materials (IST2, IST3, IST6, PST10). IST2 referred to students' interaction with the worksheets and said: *"(...) We prepared a moving objects worksheet. The child opens a video, turns to a different area, or I say (...) 'I drew a square in math, draw bees on the corners of the squares'. What does the child do? S/he use the picture, and hence we can make the child active. (...) You know, it can address many areas that we call multiple intelligences."* The same participant (IST2) thought that 5E learning cycle enables gradual learning, and s/he said: *"The 5E learning model will enable the child to make systematic progress or the child will not say 'I got stuck on the first question, it will all go like this', but they will be able to progress as they can"* In addition, a few participants stated that control over students' work can be achieved more easily in 5E-DWS (IST6, PST10, PST11). On the digital worksheets that offer teachers the chance for instant control and feedback, PST10 said: *"Instant feedback, instant answers are a great contribution. The child makes a mistake in the worksheet or in the exam, maybe we won't be able to cover them. So, in digital worksheets, we say you made a mistake here, in this sense, it saves us from wasting time and we can attend to the child one-on-one (...)"*

IST1 and IST6 commented that pen-and-paper worksheets are suitable for traditional teaching models. IST1 suggested that the digital worksheet allows the student to explore, understand and comprehend more, and then added: *"(...) Okay, it is important, it is also important to see it on paper, but I don't think it will be as effective as the other one, I don't think it will be as efficient as the digital worksheet."* Compared to the pen-and-paper worksheet, the participants stated that the digital worksheet meets the learning needs of new generation children (IST4, IST6, PST7, PST9, PST12), provides a learning environment suitable for the digital age (IST3, IST4, IST6, PST9, PST11, PST12), and supports individual learning by making students active (IST2, IST3, IST4, PST10). The opinion of IST4, who stated that digital worksheets suitable for the digital age attract the new generation children's attention more, is as follows:

> *"It is very easy to make changes on the digital worksheet (...)it is very appropriate for the new generation of children. Children don't even want to use a pencil and eraser now. They don't like writing either. (...) For example, I want to have a paper printout in my hand while reading. But this is not how the new generation grew up. Their understanding of education is not like that. Therefore, such digital worksheets are a must. I mean, even when I photocopy the practice test, their interest is less. There are digital practice tests."*

IST4 emphasized that the students themselves are active in the digital worksheets and said*: "(...) the slider and button feature being movable, taking it down, taking it up, trying it a few times, speeding it up, slowing it down... The child can make inferences. They can express themselves by saying, 'Teacher, the hundreds moved like this, teacher, look, the ones moved like this'.'"* IST4 explained that pen-and-paper worksheets prevent students from exploring and being active, but in digital worksheets, students comprehend the topics by making sense of them, so the teacher can associate the subject in a comfortable way. On the other hand, PST11 stated that pen-and-paper worksheets are easy to use, but digital worksheets would make the teacher's job more difficult. PST11 remarked: "*Pen-and-paper worksheets will be easier, ready-made, copy, paste, print. But in digital worksheets, the teacher will work, think, think about what more s/he can do. So of course, digital worksheets will be more labor-intensive for the teacher."* Although the participants had difficulties in preparing 5E-DWSs that are appropriate to the nature of mathematics and focus on discovery, they stated that they are much more useful in learning environments afterwards.

Participants mentioned many advantages of digital worksheets but pointed out that the lack of a concrete material is a disadvantage (IST4, IST5, PST8, PST9, PST11). The views of PST9, who emphasized the positive aspect of pen-and-paper worksheets in this regard, can be given as an example: *"It is a good practice in terms of being held by hand and being visible. (...) It is a good thing to do it by seeing and touching it there."* The teachers expressed positive opinions about the dynamic nature of digital worksheets (IST1, IST2, IST4). They emphasized that the fact that digital worksheets are movable, that students can explore the subject by moving the sliders themselves, and that they offer visual and auditory content is a positive aspect compared to pen-and-paper worksheets.

Phases of 5E Learning Cycle During the Preparation Process

As presented in Table 7, the participants' opinions about the phases of 5E learning cycle during the preparation process of the digital worksheets were obtained, and the data were divided into sub-themes by categorizing them as challenging and enjoyable.

Table 7. Opinions on the phases of 5E learning cycle during the preparation process of digital worksheets

Phases of 5E Learning Cycle During the Preparation Process		
Sub-themes	**Codes**	**Participants**
Challenging	Engagement	IST3, PST10, PST12
	Exploration	IST2, IST4, PST7, PST8, PST9, PST11, PST12
	Elaboration	IST1, IST5, IST6, PST9, PST12
	Evaluation	IST5
Enjoyable	Engagement	IST5, PST9, PST12
	Exploration	IST1, IST4, IST5, IST6, PST10, PST12
	Elaboration	PST7, PST8, PST11, PST12
	Evaluation	IST2, IST3

This theme addresses the reflections of the participants' experiences related to the phases of the 5E learning cycle in the process of preparing 5E-DWS. The participants highlighted the points that they enjoyed and had difficulties in the phases of the 5E learning cycle model regarding their experiences in the process of preparing 5E-DWS. It was observed that most of the participants had difficulty in the exploration phase (IST2, IST4, PST7, PST8, PST9, PST11, PST12), while the most enjoyable phase was again exploration (IST1, IST4, IST5, IST6, PST10, PST12). For example, IST4 and PST12 both stated that they had a lot of difficulty in the exploration phase yet emphasized that exploration was the phase they enjoyed the most. PST12 reported that s/he both enjoyed and struggled a lot during the exploration and engagement phases. This participant supported his/her words with the following statements: *"(...) we also put a cartoon in the engagement. It was very fun to prepare the cartoon. In the exploration phase, I couldn't do anything, I just jumped from here to there. Later, when I started doing it, I realized that it was really enjoyable."*

Similarly, IST4 expressed that s/he likes the exploration phase a lot and said: *"(...) after I figured it out, it was easier for me. (...) It made me feel more pleasure as if I discovered it, and what I liked the most during the engagement phase is this. I don't need to talk a lot to teach while explaining the subject. I say 'Look, children, you see, there is no need to explain.'"*

PST9, who both felt challenged and enjoyed the exploration phase, likened this phase to labor pains and expressed her/his words in the following sentences: *"(...) during the engagement phase, I had a hard time wondering what we could do to make children discover in the right sense. But this difficulty led to this. For example, like a mother going through labor pains, something beautiful happened in the end."* On the other hand, PST9 mentioned that s/he had difficulties both in terms of attracting children's attention in the virtual environment and in finding materials in the GeoGebra database at the primary school level. In addition, this participant reported that s/he integrated materials from different applications and internet-based sites into GeoGebra to solve the problem of not finding materials related to the subject. On the reason of being challenged in the exploration phase, PST9 said: *"(...) Also, the reason why we had difficulty was that we could not find anything ready-made about our learning outcome (in the GeoGebra database), we wondered 'what can we do, which applications can we get help from?'. This challenged us."* and added that they enjoyed a lot as they learned in all phases, especially in the elaboration phase, and as they got into the practice. PST9 also supported this by saying: *"Oh, we started doing something, we left our own identity. We took on the mind of the child."* IST5 expressed that he had difficulties during the evaluation phase, while IST2 and IST3 enjoyed this phase very much. IST3 enjoyed the evaluation phase and explained the reason as: *"(...) the phase I enjoyed is the evaluation phase for me. Because I wanted to see what was at the end, (...) in fact, the most enjoyable phase for me was the evaluation phase because I wanted to see whether the child had learned or not, whether the child had benefited or not."* This participant (IST3) also mentioned that he had difficulty in finding topics and content that would attract students' attention in the engagement phase.

Experiences of practice in learning environment

The findings regarding the participant's experiences of practice of 5E learning cycle supported digital worksheets in the learning environment are presented in Figure 4 and Table 8.

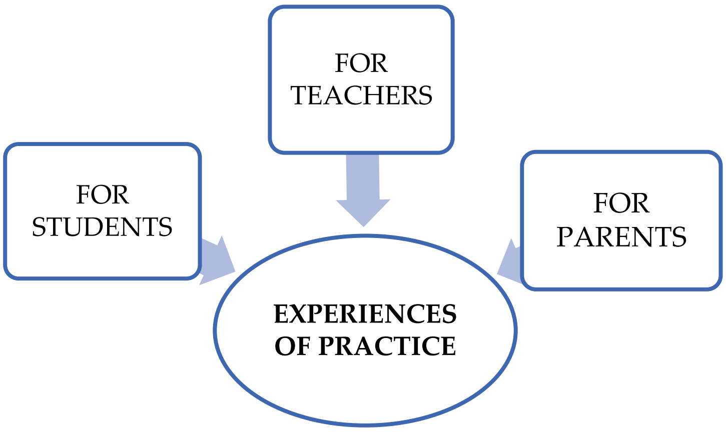

Figure 4. Experiences regarding the practice of 5E learning cycle supported digital worksheets

Table 8. Experiences regarding the practice of 5E learning cycle supported digital worksheets

Experiences of Practice		
Sub-themes	**Codes**	**Participants**
For students	Challenging at first	IST1, IST2, IST3, IST4, IST6
	Unfamiliar with technology	IST2, IST5
	Unusual	IST3
	Non-educational use of technology	IST4
For teachers	Hard to use	IST5, IST6
For parents	Not being tech-savvy	IST2, IST3

In-service primary school teachers prepared 5E-DWSs and used these digital worksheets in their classrooms. Their opinions about what experiences they had while using the digital worksheets were consulted. In line with these opinions, categories were created from the perspective of students, teachers and parents and divided into sub-themes accordingly.

a. For students

This sub-theme reflects the participants views on their practice experiences of 5E-DWS in the classroom environment from the perspective of students. Some of the in-service primary school teachers used the digital worksheets and stated that students have difficulties using these unusual digital worksheets in regions where technology is not used widely. They also added that in schools where students use technology intensely, students are challenged at first, but they get adapted quickly (IST1, IST2, IST3, IST4, IST6). Another teacher argued that students were engaged in non-educational activities when they were supposed to use the digital worksheets. IST2 reported that students had difficulty at first while using the digital worksheets, but things got easier as they practice, with these remarks: *"I can't say it wasn't difficult, it was difficult. (...) When I send the link, they say 'where do I click?' (...) I have this problem mostly with my students in the villages. Children who are not tech-savvy sometimes have difficulties in knowing where to click and how to proceed. But this will not stay like this. I think it can be improved as we use it."* Similar to this teacher, IST5 argued that the children in village experience this problem because they are not competent in technology. Another teacher (IST1), who stated that s/he teaches in a disadvantaged area, said: *"Children can handle it. The problem is with a few children; they are the children who have difficulty in every lesson. Because they have problems in understanding, and they are far from technology. We are a little bit in the suburbs. (...) But since the majority have computers at home, they like it when they are familiar with it"* and mentioned that the new generation of children growing up in the digital age adapt easily. IST3 added: *"It is a situation that students are not used to. Because it is the first time they have encountered it"* and stated that they had difficulties at first, but then they adapted very easily. IST4, who works in a central and socioeconomically well-off school, explained that s/he demonstrated the use of the software and digital worksheets in the classroom environment in case the students had difficulties in using this new teaching material. One teacher reported that students used the digital worksheets sent home for non-educational purposes (IST4). On this, IST4, based on the parents' feedback, stated: *"They (parents) just say: 's/he takes the computer and the phone for the worksheet, then s/he doesn't come for two hours'. We ask: 'What are you doing?' and s/he says, 'I'm doing my teacher's homework and study'. But he plays games."*

b. For teachers

This sub-theme reflects the views of the participants in which the experiences of using 5E-DWS in the classroom environment were evaluated from teachers' perspectives. In-service primary school teachers IST5 and IST6 thought that using digital worksheets is difficult for teachers. IST6, highlighting that they had difficulty when they first met GeoGebra, said: *"We actually didn't understand it at first. (...) Then, when we prepared it ourselves, we came to present it. (...) over time, it caught our attention."* and added that it is a very good teaching material with these remarks: *"It's that good, I love it, I sent it directly to my students."*

c. For parents

This sub-theme reflects the views of the participants in which the use experiences of 5E-DWS in the classroom environment were evaluated from the perspective of parents. In-service primary school teachers IST2 and IST3 stated that they experienced problems due to the parents' lack of familiarity with technology. IST2 said: *"Some of our parents are not yet ready for such digital activities."* and IST3 told: *"If I ask parents, they say, 'Oh, how will it be? We can't do it, we can't understand it, it doesn't work,' so the most important thing is to explain it them well."* IST3 added that problems will disappear when digital worksheets are properly communicated to parents and students.

Contents of 5E learning cycle supported digital worksheets

The documents of the 5E-DWSs were analyzed. Findings regarding the teaching instruments used in the contents of the digital worksheets are presented in Table 9. The phases of the 5E learning cycle (engagement, exploration, explanation, elaboration and evaluation) were determined as sub-themes. The codes were generated out of the data regarding the contents of the teaching materials used in these phases.

Table 9. The contents of 5E learning cycle supported worksheets

Contents of The Digital Worksheets		
Sub-themes	**Codes**	**Documents**
Engagement	Real-life problem	D2, D3, D6, D7, D10
	Video	D7, D8
	Game	D4
	Digital story	D1
	GeoGebra material	D5, D9
	Static modelling	D5
Exploration	Dynamism with sliders	D1, D3, D4, D6, D7, D9
	Dynamism with input box	D4, D5, D6, D7, D8, D10
	Static image	D2
Explanation	Instruction through video	D1, D2, D3, D4, D8, D9
	Written content	D3, D4, D5, D6, D7, D9, D10
Elaboration	Static modelling	D1, D6, D7
	Dynamism with sliders	D3, D5, D10
	Gamification	D2, D4
	Reinforcement with questions	D5, D9, D10
	Storytelling	D7, D8
	Song	D2
	Digital painting	D9
Evaluation	Gamification	D2, D4, D5, D7, D8, D9, D10
	Open-ended questions	D1, D4, D5, D6, D7, D8
	Multiple-choice questions	D1, D2, D3, D4, D5, D9
	Matching	D5

This theme reflects the participants' preferred techniques and the elements offered by the software regarding the content of the 5E-DWS they prepared. It was observed that the participants generally introduced the lesson using real-life problems while preparing 5E-DWSs (D2, D3, D6, D7, D10). They also variegated it with intriguing images, games, videos, static models, and digital stories. The contents in the 5E-DWSs were developed to identify students' readiness levels and activate their prior knowledge. The image of the game in the engagement phase of D4 is provided in Figure 5. While preparing this, the participant made use of a website other than GeoGebra.

Figure 5. A sample game used in the engagement phase of a 5E-DWS

In the exploration phase, they used explorative contents using the slider and input box features of the GeoGebra software, indicating that the participants made use of dynamic characteristics of the GeoGebra software in the exploration phase (D1, D3, D4, D5, D6, D7, D8, D9, D10). In the 5E-DWSs, contents that will enable students to learn on their own actively were used. In this phase, the participants generally developed the contents themselves. The tools available in the interface of the GeoGebra software enable teachers to create teaching materials using sliders and applets. D4 made use of dynamism in the exploration phase using input boxes and sliders. The images regarding the contents of the D4 are presented in Figure 6 and Figure 7.

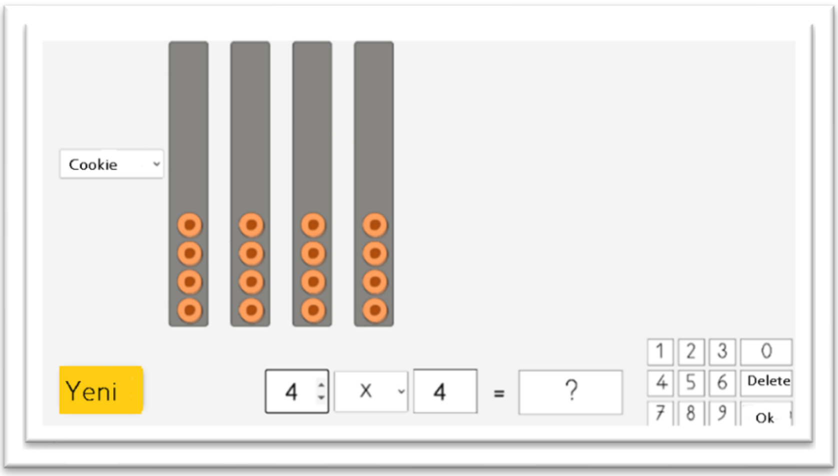

Figure 6. The dynamic visual with input box used in the exploration phase of a 5E-DWS

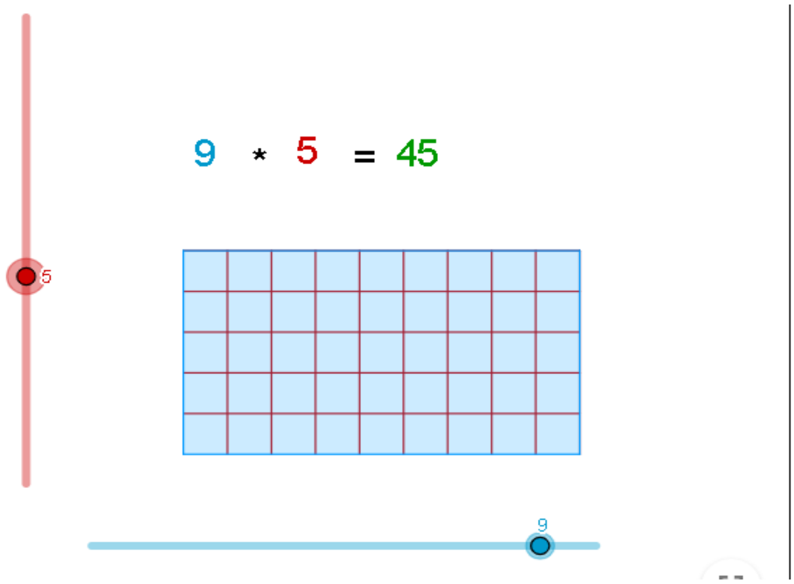

Figure 7. A dynamic visual with sliders used in the exploration phase of a 5E-DWS

Before presenting the visual contents provided in Figure 6 and 7, students were instructed. Before the dynamic visual with the input box, the students were instructed as: *"In the activity given below, observe the results by changing the indicator columns and changing the options"*; before the dynamic visual with sliders, they were told: *"Observe and interpret the results of changing the numbers by dragging the indicator columns."* Students will proceed according to the instructions and follow the phases step by step.

In the explanation phase, the participants mostly used ready-made materials (pdf files, videos, textbooks etc.). In this phase, the contents related to the subject of the 5E-DWS were communicated through written texts (D3, D4, D5, D6, D7, D9, D10 or videos (D1, D2, D3, D4, D8, D9). Videos and written materials were generally composed of contents that are not available in GeoGebra and that are ready-made. In the explanation phase of D4, both written and video lecture were present. The images regarding the explanation phase of D4 are presented in Figure 8 and Figure 9.

In multiplication, numbers are multiplied and added. In some problems, multiplication can be done instead of addition to reach the result in a shorter time.

Samples:

1.A. Samet, Ali and Koray have a total of five pencils each. What is the total number of pencils these three friends have?

Annotated solution: Addition and multiplication can be used to get the result.

Method 1: 5 + 5 + 5= 15

Method 2: 5 X 2= 15

1.B. Selma and Serpil each have 100 books in their bookshelves. If Selma and Serpil combine their bookshelves, how many books will they have?

Annotated solution: In this problem, as in the first example, we can reach the result by doing either addition or multiplication.

Method 1: 100 + 100 = 200

Method 2: 2 X 100 = 200

Figure 8. The written lecture used in the contents of the explanation phase in a 5E-DWS

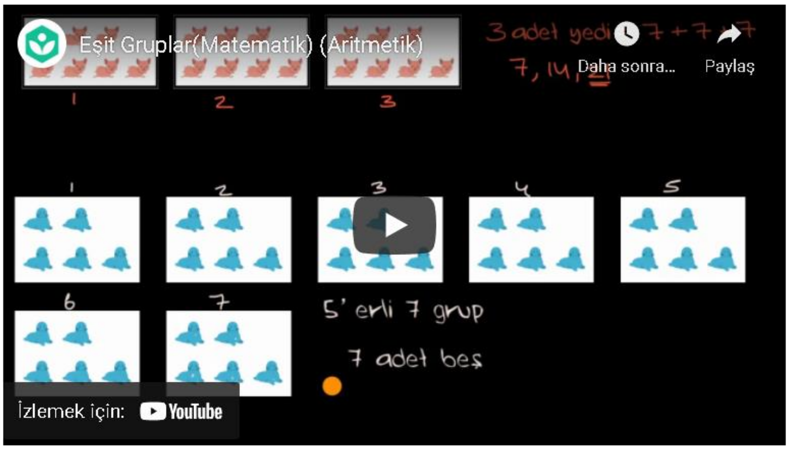

Figure 9. The video lecture used in the contents of the explanation phase in a 5E-DWS

As seen in Figure 8 and Figure 9, lecture can be in the written or video format in the explanation phase. The video used in D4 was taken from a ready-made content.

In the elaboration phase, contents aiming reinforcement were used mainly. Contents for students to reinforce their knowledge were created using sliders and models as in the exploration phase (D1, D3, D5, D6, D7, D10). Besides, there were interactive games making use of various technological and digital teaching tools and websites for reinforcement and developing the learned knowledge (D2, D4). In some digital worksheets, the contents were presented through storytelling the subjects (D7, D8), supported with questions (D5, D9, D10), and involved digital painting and other activities (D9). Figure 10 demonstrates an image regarding the game in D4. In the game used in the elaboration phase of D4, students are provided with instructions to match the models with the multiplication operations, and they are expected to complete this phase.

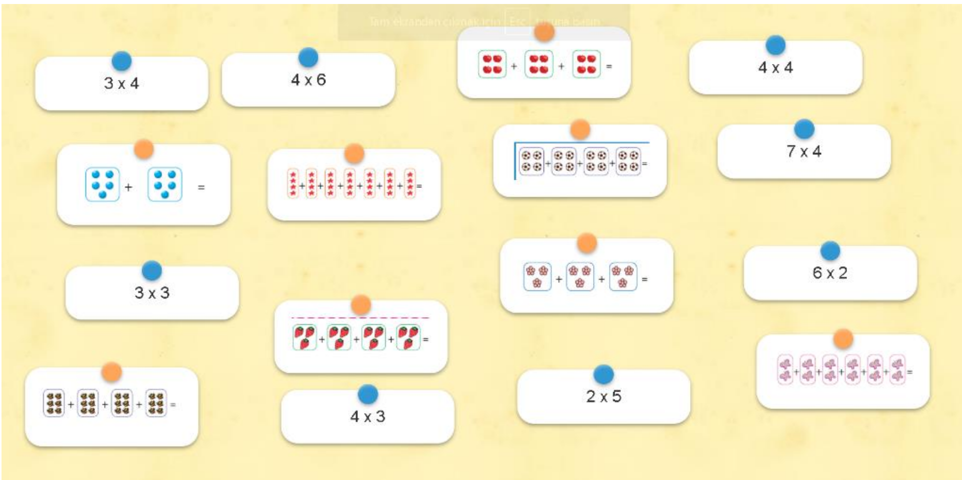

Figure 10. Image from the matching game used in the elaboration phase of a 5E-DWS

Finally in the evaluation phase, the participants intensely made use of games created with various applications in their 5E-DWSs to be able to evaluate students and provide feedback to them (D2, D4, D5, D7, D8, D9, D10). Additionally, they used open-ended (D1, D4, D5, D6, D7, D8), multiple-choice (D1, D2, D3, D4, D5, D9), and matching questions (D5). In this phase, the participants mostly used ready-made materials. They used different Web 2.0 tools such as learning app, wordwall, coolmath kids, ICT games, quizizz, and quizlet to gamify the evaluation phase. In the evaluation phase of D4, the contents included multiple-choice and open-ended questions using different Web 2.0 tools. The images from the evaluation phase of D4 are presented in Figure 11.

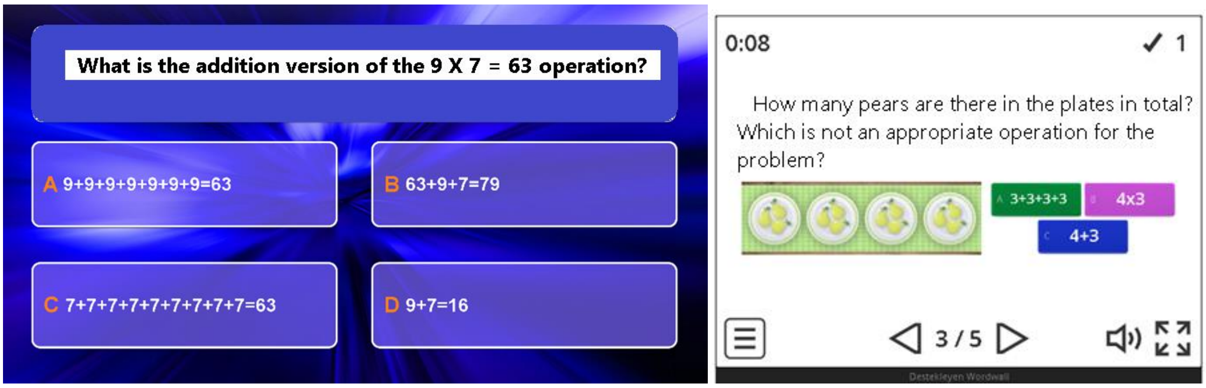

Figure 11. Images from the games used in the evaluation phase of a 5E-DWS

Discussion, Conclusion, Recommendations

This study aimed to examine the in-service and pre-service primary school teachers' practices, experiences, and opinions regarding the 5E-DWSs they prepared on GeoGebra. To this end, the study revealed findings as to 5E-DWSs, phases of 5E learning cycle in the preparation process, learning domains and subjects, advantages and disadvantages, in-service teachers' experience of practice, comparison of pen-and-paper and digital worksheets and contents of the 5E-DWSs.

It was observed that the participants association 5E-DWS particularly with contemporary approaches and constructivist approach. They stressed the digital characteristics of 5E-DWS and highlighted its contemporary and versatile nature. In line with this finding, a study reported that digital worksheets enrich learning environments for both students and teachers with text, video, visual and interactive content, moving away from a structure with only questions such as multiple-choice tests (Serth et al., 2019). In this respect, as the participants pointed out, we can argue that 5E-DWS is also in line with the constructivist approach emphasized in the curriculum revised by the Ministry of National Education in 2005 (MoNE, 2005). As the reflection of the constructivist approach, the participants stated that 5E-DWS allows students to be active and interactive and to associate the learning outcomes with daily life. Studies (Arifin, 2014; Ito et al., 2018), which show that digital worksheets enable students to learn interactively, actively and deeply, also support the findings of this study. Thus, we can suggest that 5E-DWS is a teaching material that supports doing-experiencing and explorative learning and enables students to construct concepts in their minds. Similarly, there are studies indicating that such digitally supported learning has a positive effect on addressing misconceptions (Ichsan et al., 2020; Mahtari et al., 2020).

The participants created their 5E-DWSs mainly in the numbers and operations learning domain. None of them prepared a digital worksheet in the "data" learning domain. Only two in-service teachers prepared worksheets in the geometry learning domain and a single teacher prepared a 5E-DWS in the measurement learning domain. Although some studies reported findings that teaching geometry using the GeoGebra software has a positive effect (Baltacı et al., 2015; Shadaan & Leong, 2013), the participants in the current study did not prefer 5E-DWS in the geometry learning domain at all. This may stem from the fact that the numbers and operations learning domain constitutes a very large part of the primary school mathematics curriculum. The in-service primary school teachers prepared their 5E-DWSs in line with the learning domain they teach in their own classes and that are appropriate for the related subject.

The participants reported that 5E-DWS, which adopts a student-centered approach, provides permanent, progressive, effective, fun and fast learning opportunities. These views are supported by other studies, which indicate that digital worksheets offer an exciting and effective learning environment and trigger students' interest and motivation (Arifin, 2014; Lestari et al., 2021). The participants also claimed that 5E-DWS concretizes abstract mathematical concepts with the visual elements and modeling opportunities provided by the software. Accordingly, this finding suggests that 5E-DWS contributes to the reinforcement of new concepts and knowledge by structuring them in a concrete way. Therefore, it is thought that the online nature of the 5E-DWS contributes to teachers' timely interventions, their ability to identify students' problems and possible mislearning, and the elimination of students' misconceptions. The related literature suggests that worksheets that are in accordance with the constructivist approach and guide students in their practices help to improve students' conceptual understanding (Kolomuc et al., 2012). Serth et al. (2019) also lend their support to this result.

Participants emphasized that 5E-DWS encourages especially active learning with a student-centered approach and supports individual learning by involving all students. In favor of these findings, another study found that digital worksheets contribute to students' individual learning in an interactive way (Serth et al., 2019). Additionally, as highlighted in the current study, Ulaş et al. (2012) also revealed that the gradual learning opportunity offered by worksheets designed with the 5E learning cycle encourages students' individual learning. Taking into account students' needs and individual differences, 5E-DWS provides disadvantaged students with a learning environment that is flexible and appropriate to their learning potential. Besides, the participants also noted that it is a flexible teaching material that can help students reach higher level learning outcomes. This may be due to the fact that digital worksheets offer students a function to increase their independence, and their use is not only limited to school (Dwijayani, 2019) but also provides the opportunity to learn at home (Lestari et al., 2021). In the same vein, Salim et al. (2021) indicated in their study that technology-based worksheets are flexible materials that students can access anytime and anywhere in accordance with their own learning needs.

5E-DWS, which triggers students' curiosity and motivation, also helps teachers to renew themselves, to lean on different areas, to be active, and to develop materials in accordance with the needs of their classes. The participants argued that 5E-DWS can also be used effectively in distance education processes thanks to its advantages such as offering gradual learning, supporting individual learning, and having a dynamic structure. Correspondingly, the literature posits that digital worksheets can offer an alternative learning environment in situations requiring distance education (Sari et al., 2021). A study reported that technology-based worksheets positively support students' active and individual learning in the distance education process (Salim et al., 2021). It is also claimed that digital worksheets, in which teachers can take an active role in distance education, are suitable for learning (Ichsan et al., 2020). Beside its advantages, the participants also pointed out to the disadvantages of 5E-DWS. These disadvantages are due to lack of technological equipment and insufficient prior knowledge of teachers and students. Participants also reported that 5E-DWS individualizes students. Contrary to the views of the participants that 5E-DWS individualizes students, another study reports that digital worksheets prepared with "Fliphtml5" improve collaborative learning and creativity (Lupi et al., 2021). This may indicate that digital worksheets prepared with different platforms support collaborative learning, contrary to some participants' views on GeoGebra. In a similar study, Arifin (2014) emphasized that digital worksheets improve students' communication skills, but as a disadvantage, technological environments are used for different non-educational purposes and in this respect, the need for control is emphasized. The emphasis on the need for control expressed in the current study also supports the findings of the related study.

This study sought the opinions of only the in-service teachers about their experiences of practicing the digital worksheets in the learning environment. While the in-service primary school teachers reported that students in disadvantaged regions could not adapt because they were not competent in technology use, it was concluded that students in socio-economically and socio-culturally advantageous regions adapted easily. With respect to teachers, it was difficult for them to use the worksheets since they were not familiar with them. According to the feedback they received from parents, teachers reported problems related to parents' inability to use technology.

The participants were of the opinion that, compared to 5E-DWS, pen-and-paper worksheets are not economical, and they are only for single-use. In addition, there were comments about digital worksheets being fun and interesting and pen-and-paper worksheets being boring and anxiety-provoking. Pen-and-paper worksheets were reported to have a restrictive and traditional perspective. According to Sujatmika et al. (2019), pen-and-paper worksheets have a limited structure consisting only of images and text, while digital worksheets offer interactive learning environments with visual content such as audio and video. Supporting these views, Yılmaz (2004) argues that worksheet is a modern and effective method that saves education from traditionality and increases achievement, but it will not affect achievement positively if not based on the computer-aided instruction model. Therefore, it is an advantage that 5E-DWS is appropriate for the digital age and can meet the learning needs of new generation students by enabling multidimensional, explorative, interactive and gradual learning environments. The literature also emphasizes that pen-and-paper worksheets are not needed for visualizing objects, presenting content practically, and allowing students to be active and explore (Bakri et al., 2020). While the participants pointed out that pen-and-paper worksheets are positive in terms of being tangible and satisfying the students with the sensation of tact, they highlighted the dynamic feature of 5E-DWS. In a study examining the effect of pen-and-paper and digital worksheets created with the REACT supported learning model on students' problem-solving skills, it was revealed that the model was effective, although there was no significant difference between the two types of worksheets (Suhendi et al., 2019). Although this study revealed that there was no difference between digital and pen-and-paper worksheets, it can be said that both types of worksheets developed with different models can have positive effects. Additionally, regarding the phases of 5E learning cycle, the participants expressed that they enjoyed the process of preparing digital worksheets most in the exploration and elaboration phases. On the other hand, it was revealed that they had the most difficulty in the same phases of exploration and elaboration.

An examination of the 5E-DWSs the participants prepared suggests that they aimed to identify students' readiness levels and activate their prior-knowledge through making associations with daily life and supporting with visual and audio tools in the contents of the engagement phase. In the engagement phase, the participants used intriguing questions, videos, images, and games. As Bybee and Landes (1990) state, the engagement phase should lay the groundwork for the knowledge, concepts, and processes to be explored by utilizing students' previous experiences and mobilizing their readiness. In the exploration phase, the participants made use of the dynamism features of GeoGebra software for students to make inferences and comparisons. In this phase, they used the dynamism feature with the sliders and input boxes. Çetin et al. (2015) stated that the digital worksheets they prepared with GeoGebra helped middle school students learn by doing by providing the opportunity to move and drag the shapes. In the explanation phase, the participants mostly included screenshots and videos taken from pdf files and textbooks. In the elaboration phase, similar to the exploration phase, they mostly used drawing boards, dynamism with sliders, interactive games, reinforcement with questions, storytelling, songs, and digital painting contents thanks to the features of GeoGebra. In the elaboration phase, teachers encourage students to associate new knowledge and concepts with the real life (Goldston et al., 2010). In this phase, it is aimed for students to reinforce their concepts and knowledge, practice them and recommend solutions (Bybee et al., 2006; Kolomuc et al., 2012). In this sense, we can conclude that the majority of the contents in the elaboration phase of the 5E-DWSs analyzed in this study were appropriate. The final phase of the 5E learning cycle, the evaluation phase, attempts to provide students feedback in order to evaluate whether they have correctly understood the new knowledge and concepts they have acquired and the progress they have made (Bybee, 2014; Wilder & Shuttleworth, 2005). In this study, the participants included gamification, open-ended questions, multiple-choice questions, and matching elements in order to obtain feedback from the students in the evaluation phase of the prepared 5E-DWSs.

It is a limitation that the present study was conducted with 12 participants. Therefore, further qualitative, or quantitative research studies involving more participants may contribute to the literature. The present study provides a framework by addressing only the opinions and experiences of in-service and pre-service primary school teachers. In line with this limitation, the evaluation of the applicability of 5E-DWS in learning environments from the perspective of primary school students can contribute to the related literature. In addition, the experiences and practices of primary school students regarding 5E-DWS can be examined through methods such as experimental or action research. This study was conducted with in-service and pre-service primary school teachers. Studies in which the opinions of in-service and pre-service teachers at different levels about 5E-DWS can also be conducted. In this study, opinions about the 5E-DWS prepared with the mathematics software GeoGebra were obtained. In other fields, it may be recommended to conduct studies investigating the effectiveness of digital worksheets prepared using different learning models and different software in terms of teachers and students. This study sought the opinions of in-service and pre-service primary school teachers on 5E-DWS and they generally submitted positive opinions, providing some clues regarding the applicability of 5E-DWSs in primary school classrooms. Therefore, expanding the studies in which 5E-DWS designed with GeoGebra software at primary school level is evaluated in the context of mathematics teaching can contribute to the related literature. It may be recommended to conduct studies in which the effects of digital and pen-and-paper worksheets on students' mathematics achievement and attitudes are investigated and compared.

References

Akar, H. (2016). Durum çalışması. In A. Ersoy & A. Saban (Eds.), *Eğitimde nitel araştırma desenleri* (pp. 111-150). Ankara: Anı Yayıncılık.

Anderson, A. (1995). Creative use of worksheets: Lessons my daughter taught me. *Teaching Children Mathematics, 2*(2), 72-79.

Arbain, N., & Shukor, N. A. (2015). The effects of geogebra on students achievement. *Procedia - Social and Behavioral Sciences, 172*, 208-214.

Arifin, H. R. (2014). Developing English interactive multimedia students e-Worksheet for fourth graders of elementary school. *Language Circle: Journal of Language and Literature, IX*(1), 73-83.

Arslan, M. (2016). Aktif öğrenme. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 6*(2), 92-105.

Bahtaji, M. A. A. (2021). The role of math and science exposure on the effect of 5E instructional model in physics conceptions. *Journal of Baltic Science Education*, *20*(1), 10-20.

Bakri, F., Permana, H., Wulandari, S., & Muliyati, D. (2020). Student worksheet with AR videos: Physics learning media in laboratory for senior high school students. *JOTSE: Journal of Technology and Science Education, 10*(2), 231-240.

Baltacı, S., Yıldız, A., & Kösa, T. (2015). Analitik geometri öğretiminde Geogebra yazılımının potansiyeli: Öğretmen adaylarının görüşleri. *Turkish Journal of Computer and Mathematics Education, 6*(3), 483-505.

Bilgin, T., & Acar, C. (2007). İlköğretim II. kademede matematik konularının öğretiminde aktif öğrenme yöntemlerinin kullanımını yaygınlaştırma. *SAÜ Eğitim Fakültesi Dergisi, 14*, 115-130.

Boztaş, H. (2012). *İlköğretim 8. sınıf matematik dersi üçgenler alt öğrenme alanının öğretiminde aktif öğrenme yaklaşımının öğrencilerin başarısına ve kalıcılığına etkisi* (Unpublished master's thesis). Gazi University, Ankara.

Bybee, R. W. (2014). Guest editorial: The BSCS 5E instructional model: Personal reflections and contemporary implications. *Science and Children, 51*(8), 10-13.

Bybee, R. W., & Landes, N. M. (1990). Science for life ve living: An elementary school science program from biological sciences curriculum study. *The American Biology Teacher, 52*(2), 92-98. doi:10.2307/4449042

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). *The BSCS 5E instructional model: Origins, effectiveness and applications*. Colorado Springs: BSCS.

Celikler, D., & Aksan, Z. (2012). The effect of the use of worksheets about aqueous solution reactions on pre-service elementary science teachers' academic success. *Procedia - Social and Behavioral Sciences, 46*, 4611-4614.

Creswell, J. W. (2019). *Nitel araştırmacılar için 30 temel beceri* (H. Özcan, Trans.). Ankara: Anı Yayıncılık.

Creswell, J. W. (2020). *Eğitim araştırmaları: Nicel ve nitel araştırmanın planlanması, yürütülmesi ve değerlendirilmesi* (3rd ed., H. Ekşi, Trans.). İstanbul: EDAM Yayınları.

Creswell, J. W. (2021). *Nitel araştırma yöntemleri: Beş yaklaşıma göre nitel araştırma ve araştırma deseni* (S. B. Demir & M. Bütün, Trans.). Ankara: Siyasal Kitabevi.

Çetin, İ., Erdoğan, A., & Yazlık, D. Ö. (2015). Geogebra ile öğretimin sekizinci sınıf öğrencilerinin dönüşüm geometrisi konusundaki başarılarına etkisi. *Uluslararası Türk Eğitim Bilimleri Dergisi, 2015*(4), 84-92.

Demir, M., Zengin, Y., Özcan, Ş., Urhan, S., & Aksu, N. (2022). Students' mathematical reasoning on the area of the circle: 5E-based flipped classroom approach. *International Journal of Mathematical Education in Science and Technology*, 1-25. doi:10.1080/0020739X.2022.2101955

Demirci, S. (2019). *Dijital çalışma yaprakları ile desteklenmiş kavram karikatürlerinin sosyal bilgiler dersi coğrafya konularının öğretiminde kavramsal anlamaya etkisinin karşılaştırılması* (Unpublished master's thesis). Trabzon University, Trabzon.

Dwijayani, N. M. (2019). Effect of worksheet aided geogebra on mathematical communication skill. In *1st International Conference on Cybernetics and Intelligent System (ICORIS) 22-23 August 2019* (pp. 242-245). Bali, INDONESIA: IEEE.

Er Nas, S., & Çepni, S. (2011). Derinleşme aşamasına yönelik geliştirilen çalışma yapraklarının etkililiğinin değerlendirilmesi. *Türk Eğitim Bilimleri Dergisi, 9*(1), 125-150.

Erna, M., Elfizar, E., & Dewi, C. A. (2021). The development of e-worksheet using kvisoft flipbook maker software based on lesson study to improve teacher's critical thinking ability. *International Journal of Interactive Mobile Technologies (iJIM), 15*(1), 39-55. doi:10.3991/ijim.v15i01.15679

Felder, R. M., & Brent, R. (1996). Navigating the bumpy road to student-centered instruction. *College Teaching, 44*(2), 43-47.

Glesne, C. (2020). *Nitel araştırmaya giriş* (A. Ersoy & P. Yalçınoğlu, Trans.). Ankara: Anı Yayıncılık.

Goldston, M. J., Day, J. B., Sundberg, C., & Dantzler, J. (2010). Psychometric analysis of a 5E learning cycle lesson plan assessment instrument. *International Journal of Science and Mathematics Education, 8*(4), 633-648.

Gültekin, M. (2020). Cumhuriyet Dönemi ilkokul programlarındaki gelişmeler. In M. Gültekin (Ed.), *Cumhuriyet Dönemi ilkokul programları* (1st ed., pp. 1-74). Ankara: Pegem Akademi.

Güven, B., & Yılmaz, G. K. (2012). Dinamik geometri yazılımı kullanımının sınıf öğretmeni adaylarının dönüşümler konusundaki akademik başarılarına etkisi. *Education Sciences, 7*(1), 442-452.

Haciomeroglu, E. S., Bu, L., Schoen, R. C., & Hohenwarter, M. (2009). Learning to develop mathematics lessons with GeoGebra. *MSOR Connections, 9*(2), 24-26.

Hohenwarter, J., Hohenwarter, M., & Lavicza, Z. (2010). Evaluating difficulty levels of dynamic geometry software tools to enhance teachers' professional development. *International Journal for Technology in Mathematics Education, 17*(3), 127-134.

Hohenwarter, M., & Jones, K. (2007). Ways of linking geometry and algebra, the case of Geogebra. *Proceedings of the British Society for research into Learning Mathematics, 27*(3), 126-131.

Ichsan, I. Z., Rahmayanti, H., Purwanto, A., Sigit, D. V., Singh, C. K. S., & Babu, R. U. M. (2020). HOTS-AEP-COVID-19: Students knowledge and digital worksheet of ILMIZI environmental learning model. *International Journal of Advanced Science and Technology, 29*(6), 5231-5241.

Ito, A., Morimoto, Y., & Hayakawa, R. (2018). Effect of an E-worksheet management system for promoting student active learning. In *12th International Technology, Education and Development Conference (INTED)* (pp. 8398-8407). Valencia, Spain: IATED.

Jayawardana, C., Hewagamage, K. P., & Hirakawa, M. (2001). Personalization tools for active learning in digital libraries. *MC Journal: The Journal of Academic Media Librarianship, 8*(1), 1-19.

Jones, M. G., & Brader-Araje, L. (2002). The impact of constructivism on education: Language, discourse, and meaning. *American Communication Journal, 5*(3), 1-10.

Kasti, H., & Jurdak, M. (2017). The effect of GeoGebra collaborative and iterative professional development on in-service secondary mathematics teachers' practices. In *10th Congress of the European Society for Research in Mathematics Education (CERME)* (pp. 2398-2405). Dublin, Ireland.

Kolomuc, A., Ozmen, H., Metin, M., & Acisli, S. (2012). The effect of animation enhanced worksheets prepared based on 5E model for the grade 9 students on alternative conceptions of physical and chemical changes. *Procedia - Social and Behavioral Sciences, 46*, 1761-1765.

Kurt, Ş. (2001). *Fizik öğretiminde bütünleştirici öğrenme kuramına uygun çalışma yapraklarının geliştirilmesi* (Unpublished master's thesis). Karadeniz Teknik University, Trabzon.

Kutluca, T., & Zengin, Y. (2011). Belirli integral konusundaki dinamik matematik yazılımı geogebra kullanarak çalışma yapraklarının geliştirilmesi. In *5th International Computer ve Instructional Technologies Symposium*. Fırat University, Elazığ.

Lee, J. A. N. (1999). Incorparating active-learning into a web-based ethics course. In *29'h ASEE/IEEE Frontiers in Education Conference* (pp. 12d6/19-24), San Juan, PR, USA: IEEE. doi:10.1109/FIE.1999.841687

Lestari, P. C., Miriam, S., & Misbah, M. (2021). Science literacy-based sound wave e-worksheet: Validity aspects. *Journal of Physics: Conference Series, 2104*(1), 012010. doi:10.1088/1742-6596/2104/1/012010

Lindenbauer, E. (2020). *A digital worksheet for diagnosing and enhancing students' conceptions in functional thinking.* Paper presented at the 10th ERME Topic Conference, Linz, Austria.

Lindenbauer, E., & Lavicza, Z. (2021). From research to practice: Diagnosing and enhancing students' conceptions in a formative assessment tool utilizing digital worksheets in functional thinking. *International Journal for Technology in Mathematics Education, 28*(3), 133-142.

Lupi, T. P., Herlina, K., Sesunan, F., & Andra, D. (2021). Development of project based e-Worksheet to stimulate scientific creativity and collaborative skills. *BerkalaIlmiah Pendidikan Fisika, 9*(2), 222-233.

Mahtari, S., Wati, M., Hartini, S., Misbah, M., & Dewantara, D. (2020). The effectiveness of the student worksheet with PhET simulation used scaffolding question prompt. *Journal of Physics: Conference Series 1422*(012010), 1-5. doi:10.1088/1742-6596/1422/1/012010

Majerek, D. (2014). Application of Geogebra for teaching mathematics. *Advances in Science and Technology Research Journal, 8*(24), 51-54.

Martin, S. N., Irwan, Elniati, S., & Djuandi, D. (2017). The development of scientific approach based students' worksheet on trigonometry for grade X student. In *3rd International Conference on Advances in Education and Social Science* (pp. 345-355), Istanbul: ADVED.

Michael, J. (2006). Where's the evidence that active learning work?. *Advances in Physiology Education, 30*(4), 159-167.

Miles, M. B., & Huberman, A. M. (2019). *Genişletilmiş bir kaynak kitap: Nitel veri analizi* (S. Akbaba Altun & A. Ersoy, Trans.). Ankara: Pegem Akademi.

Mingirwa, I. M. (2016). Teachers' technology uptake, a case of GeoGebra in teaching secondary school mathematics in Kenya. In *IST-Africa Week Conference* (pp. 1-11). Durban, SOUTH AFRICA: IEEE.

Ministry of National Education. (2005). *İlköğretim matematik dersi 1-5. sınıflar öğretim programı.* Ankara: MEB Talim ve Terbiye Kurulu Başkanlığı.

Ministry of National Education. (2018). *Matematik dersi öğretim programı (ilkokul ve ortaokul 1, 2, 3, 4, 5, 6, 7 ve 8. sınıflar).* Ankara: Ministry of National Education.

Muskita, M., Subali, B., & Djukri. (2020). Effects of worksheets base the levels of inquiry in improving critical and creative thinking. *International Journal of Instruction, 13*(2), 519-532.

Noddings, N. (1990). Chapter 1: Constructivism in mathematics education. In R. B. Davis, C. A. Maher, & N. Noddings (Eds.), *Journal for Research in Mathematics Education. Monograph* (pp. 7-18). Reston VA: National Council of Teachers of Mathematics.

Norton, R. M. (2001). Determining probabilities by examining underlying structure. *Mathematics Teaching in the Middle School, 7*(2), 78-82.

Özçakır Sümen, Ö. (2017). Sınıf öğretmeni adaylarının temel matematik eğitiminde GeoGebra yazılımının kullanımına ilişkin görüşleri. *SOBİDER, 4*(15), 560-571.

Özmen, H., & Yıldırım, N. (2005). Effect of work sheets on student's success: Acids and bases sample. *Journal of Turkish Science Education, 2*(2), 64-67.

Paterno, M. G. (2009). Designing worksheets for critical language practice. *ELTWorldOnline.com, 1*, 1-10.

Patton, M. Q. (2018). *Nitel araştırma ve değerlendirme yöntemleri* (2nd ed., M. Bütün, & S. B. Demir, Trans.). Ankara: Pegem Akademi Yayıncılık.

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon, 9*(5), 1-6.

Salim, S. S., Darmawan, F. A., & Jainuddin, J. (2021). Augmented reality-based mathematics worksheet for online learning during Covid-19 pandemic. *Indonesian Journal of Educational Studies, 23*(2), 81-90.

Sari, D. S., Widiyawati, Y., Nurwahidah, I., Masykuri, M., & Budiyanto, C. W. (2021). The development of e-worksheet based on project to promote student's creative thinking and digital literacy skills. In *7th International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS 2020)* (pp. 647-654). Hollanda: Atlantis Press.

Selley, N. (2013). *Art of constructivist teaching in the primary school: A guide for students and teachers* London: David Fulton Publishers.

Serth, S., Teusner, R., Renz, J., & Uflacker, M. (2019). Evaluating digital worksheets with interactive programming exercises for K-12 education. In *2019 IEEE Frontiers in Education Conference (FIE)* (pp. 1-9). Covington, KY, USA: IEEE.

Sezgin Memnun, D. (2007). Permütasyon ve olasılık konularının aktif öğrenme ile öğretiminin öğrenci başarısına etkisi. *Education Sciences, 2*(4), 398-412.

Shadaan, P., & Leong, K. E. (2013). Effectiveness of using GeoGebra on students' understanding in learning circles. *Malaysian Online Journal of Educational Technology, 1*(4), 1-11.

Sholikhah, B. U., & Cahyono, A. N. (2021). Augmented reality student worksheets for learning mathematics during the COVID-19 pandemic. *Journal of Physics: Conference Series, 1918*(4), 042063.

Sönmez, V., & Alacapınar, F. (2019). *Örneklendirilmiş bilimsel araştırma yöntemleri* (7th ed.). Ankara: Anı Yayıncılık.

Suhendi, H. Y., Jamilah, N., Mulhayatiah, D., & Ardiansyah, R. (2019). REACT digital and manual worksheet for enhancing physics problem solving skill. *Journal of Physics: Conference Series, 1402*(4), 044089.

Sujatmika, S., Irfan, M., Ernawati, T., Wijayanti, A., Widodo, S. A., Amalia, A. F. ... Rahim, R. (2019). *Designing e-worksheet based on problem-based learning to improve critical thinking*. ICSTI 2018, Yogyakarta, Indonesia.

Surynkova, P. (2020). GeoGebra in secondary school education in the Czech Republic: Teachers' perceptions. In *17th International Conference on Efficiency and Responsibility in Education* (pp. 293-300), Praque: Czech University of Life Sciences Prague.

Susila, A. B., Chanifah, A., & Delina, M. (2021). Development of digital worksheet with PhET simulation on quantum physics to enhance students' HOTS. In *AIP Conference Proceeding 2320, 020041* (pp. 1-5). Melville, NY.: AIP Publishing.

Syamsu, Rahman, A., & Kade, A. (2017). Effectiveness of science learning through flash media and students' worksheet. In *1st Indonesian Communication Forum of Teacher Training and Education Faculty Leaders International Conference on Education* (pp. 243-246). Univ Tadulako Palu, Media Ctr, Palu, INDONESIA: Atlantis Press.

Tezer, M., & Cumhur, M. (2017). Mathematics through the 5E instructional model and mathematical modelling: The geometrical objects. *Eurasia Journal of Mathematics Science and Technology Education*, *13*(8), 4789-4804. doi:10.12973/eurasia.2017.00965a

Töman, U., Akdeniz, A. R., Odabasi Çimer, S., & Gürbüz, F. (2013). Extended worksheet developed according to 5e model based on constructivist learning approach. *Online Submission, 4*(4), 173-183.

Turan, S., & Matteson, S. M. (2021). Middle school mathematics classrooms practice based on 5E instructional model. *International Journal of Education in Mathematics, Science, and Technology (IJEMST)*, *9*(1), 22-39.

Ulaş, A. H., Sevim, O., & Tan, E. (2012). The effect of worksheets based upon 5e learning cycle model on student success in teaching of adjectives as grammatical components. *Procedia - Social and Behavioral Sciences, 31*, 391-398.

Wang, Q. E., Myers, M. D., & Sundaram, D. (2013). Digital natives and digital immigrants. *Business ve Information Systems Engineering, 5*(6), 409-419.

Wibawa, S. C., Cholifah, R., Utami, A. W., & Nurhidayat, A. I. (2018). Creative digital worksheet base on mobile learning. *IOP Conference Series. Materials Science and Engineering, 288*(1), 1-9.

Wilder, M., & Shuttleworth, P. (2005). Cell inquiry: A 5e learning cycle lesson. *Science Activities: Classroom Projects and Curriculum Ideas, 41*(4), 37-43.

Yıldırım, A., & Şimşek, H. (2021). *Sosyal bilimlerde nitel araştırma yöntemleri*. Ankara: Seçkin Yayıncılık.

Yılmaz, M. (2004). *Bilgisayar destekli fizik öğretiminde çalışma yapraklarına dayalı öğretim materyali geliştirme ve uygulama* (Unpublished master's thesis). Sakarya University, Sakarya.

Yohannes, A., & Chen, H. L. (2021). GeoGebra in mathematics education: A systematic review of journal articles published from 2010 to 2020. *Interactive Learning Environments*. doi:10.1080/10494820.2021.2016861

Yoma, R. P., & Armiati. (2018). Development of worksheet mathematics student based on inquiry to improve critical thinking ability. In *2nd International Conference on Mathematics and Mathematics Education 2018 (ICM2E 2018)* (pp. 285-290). Hollanda: Atlantis Press.

Yulianti, D. (2017). Problem-based learning model used to scientific approach based worksheet for physics to develop senior high school students characters. *Journal of Physics: Conference Series, 824*(1), 1-5.

Žilinskiene, I. (2014). Use of GeoGebra in primary math education: A theoretical approach. *Lietuvos Matematikos Rinkinys, 55*(A). doi:10.15388/lmr.a.2014.14

Žilinskiene, I., & Demirbilek, M. (2015). Use of GeoGebra in primary math education in Lithuania: An exploratory study from teachers' perspective. *ınformatics in Education, 14*(1), 127-142.