Journal of Educational Technology & Online Learning
Volume 5 | Issue 2 | 2022
http://dergipark.org.tr/jetol

JETOL
JOURNAL OF EDUCATIONAL TECHNOLOGY & ONLINE LEARNING

Pre-service teachers' approaches to designing technology-based activities in anchored instruction framework

Nilgün Günbaş [a] *

[a] Kafkas University, Turkey.

Suggested citation: Günbaş, N. (2022). Pre-service teachers' approaches to designing technology-based activities in anchored instruction framework. *Journal of Educational Technology & Online Learning*, *5*(2), 270-296.

Article Info

Keywords:

Anchored instruction
Mathematics activities
Design-based research
Instructional design
Pre-service teachers

Research Article

Abstract

Teachers' beliefs and skills in, and attitudes towards technology are the factors shaping their technology use in education. However, teacher preparation programs don't sufficiently support pre-service teachers in this regard. One way to improve their technology beliefs and skills in, and attitudes towards technology is to have them design theory-based technology learning environments. In this study, pre-service mathematics teachers designed anchored instruction-based mathematics learning environments and their approaches for the process were revealed. 52 pre-service teachers went through a 14-week learning period and then asked to build technology-based mathematics learning materials. Their materials were designed based on three design principles of anchored instruction. Upon the completion, projects applying all the necessary requirements in good, average, or poor level were selected with a purposive sampling method. The requirements were specified as workability, interactivity, narration, completeness and representing anchored instruction's three design principles. The designers of these selected projects were interviewed with semi-structured interview questions. Results indicated that their design approaches are in line with anchored instruction theory's suggested benefits. Their technology beliefs are positively affected and their judgments about technology-based instructional material design are supported by related literature in favor of students' learning. Implications for teacher education programs are discussed.

1. Introduction

Technology has been used extensively in every part of our lives and gained more and more importance every day. The field of education is no exception, and teachers play vital role in the integration of technology to education. This outcome is indicated in a research study with 3500 teachers from 22 different countries (Law et al., 2008). Studies with award winning technology-user teachers (Ertmer et al., 2012) and with over 1000 teachers (Miranda & Russell, 2012) point out the factors that shape teachers' technology use as their beliefs and skills in, and attitudes towards technology. In this respect, teacher preparation programs need to educate pre-service teachers on the integration of technology well to support them graduate with a good understanding of technology in education (U.S. Department of Education, Office of Educational Technology, 2017, p.1). It is also necessary that pre-service teachers have experience in learning about and designing technology to

* Corresponding author. Department of Mathematics Education, Kafkas University, Turkey.
e-mail address: ng2248@tc.columbia.edu

Doi: http://doi.org/10.31681/jetol.973076
Received 19 Jul 2021; Revised 27 Dec 2021; Accepted 22 May 2022;
ISSN: 2618-6586 .

recognize the value of technology in education. Thus, they may develop a positive attitude towards technology integration and be motivated to use technology in their future profession.

For technology integration to be successful in educational settings, teachers are required to gain essential skills such as having technological knowledge with appropriate pedagogical methods to teach their contents (Koehler & Mishra, 2009), before starting their professions. Moreover, these skills should be provided based on proven theories (Design-Based Research Collective, 2003) so that they can get the most benefit of technology use in education. Otherwise, they may go no beyond using basic presentations or drill and practice tools, which may not effectively support students' learning. Teachers are required to design and assess authentic learning experiences and assessments to expand learning (International Society for Technology Integration in Education (ISTE), 2008). Theory-supported learning conditions results with productive outcomes for students' learning experiences. Pre-service teachers designing of technology-supported learning environments, in which learning theories are applied, must be supported (Design-Based Research Collective, 2003). However, teacher education programs do not sufficiently fulfill pre-service teachers' such needs and, their beliefs, skills, and attitudes towards technology in education are not paid much attention (Uerz et al., 2018). In this regard, in this study pre-service teachers' theory-based design experiences are supported, and their technology-based design experiences are revealed. The theory was specified as anchored instruction based on Design-Based Research Collective (2003) suggestion.

In this study, it was investigated whether pre-service mathematics teachers would develop an understanding of technology integration in teaching by creating anchored instruction theory-based learning environments. Anchored instruction was utilized in the process as a theory for pre-service teachers to reveal their understanding of technology integration in education. In this study the research question was "What are pre-service mathematics teachers' design approaches of technology-based mathematics materials based on anchored instruction theory?" To address this question, 52 pre-service teachers went through a 14-week learning period and were asked to build technology-based mathematics learning platforms afterwards. The learning platforms were designed based on three design principles of anchored instruction. Upon the completion, a total of six groups of two pre-service teachers, 12 in total, were interviewed with semi-structured interview questions. Their answers were analyzed with a descriptive analysis under the themes in anchored instruction framework. It was expected that revealing pre-service teachers' theory-based design approaches would help us get better understanding of whether such experiences can be helpful for expanding their skills, attitudes, and beliefs in technology.

2. Literature

2.1. Anchored Instruction

The process of the present study, from training pre-service teachers to analyzing their products, was framed around three design principles of anchored instruction framework. Anchored instruction is based on Situated Learning and Situated Cognition theories and advocates presenting instruction in meaningful contexts (Cognition and Technology Group at Vanderbilt (CTGV), 1990). Meaningful contexts serve as a place, in which all the problems with the necessary data (e.g., hints, feedback) are embedded (i.e., embedded data design principle) in a realistic storyline (i.e., narrative principle). This context is presented to students in a video (i.e., video-based format principle) and students are expected to solve problems in a group, in which they are supposed to generate problems (i.e., generative format principle). Problems are complex in nature that necessitates students to solve each problem in at least fourteen stages (i.e., problem complexity principle). The story is presented as an adventure and the entire video includes more than one adventure (i.e., pairs of related adventures principle). Lastly, this learning environment supports linking mathematical thinking to other curriculum areas, such as science and history, since the context includes these areas-related problems as well as mathematics (i.e., links across the curriculum principle). In summary, the theory includes seven design principles (see CTGV (1997), page 46).

Information presented in schools mostly cause knowledge to remain inert (Whitehead, 1992). Inert knowledge can only be recalled when explicitly asked, otherwise it cannot be recalled in problem situations (CTGV, 1990). Learning can be situated in meaningful learning contexts and becomes meaningful. Accordingly, knowledge gained in such educational contexts will no longer remain inert (Williams, 1992). The rationale is that learning can only be shaped through the situation where it is to be used and it is way more than an inter-individual process. "There is no activity that is not situated" (Lave & Wenger, 1991, p. 33) and knowledge can be gained while performing learning activity in real-life cases (Brown et al., 1989). These are the basis of anchored instruction bringing real life situations in classrooms via video-based technology.

Anchored instruction has positive contributions to teaching and learning in different topics. Anchored instruction provides a learning environment where students can actively participate in learning, learn in more meaningful way and are more motivated (Susanto & Riyanto, 2020). In the literature, anchored instruction framework combining virtual chemistry laboratory and augmented reality (Hou & Lin, 2017), including introduction to programming in an authentic context (Magana, Falk, Vieira & Reese, 2016), and including physics concepts (Malik et al., 2021) have positive effects on students learning, self-believes, and knowledge acquisitions. Anchored instruction has been utilized for teaching mathematics in special education (Bottge et al. 2015; Castillo, 2020) and second language learning (Chen, 2019; Indriani, 2020). It was also utilized in creating effective hands-on teaching materials (Susanto, R., & Riyanto, 2020; Susanto & Lestari, 2020). In comparative studies, video-based anchored instruction has more positive effect on learners' achievement and remembering over traditional teaching (Arah et al., 2017; Kennedy et al., 2017). In teacher education, anchored instruction support mathematics teachers' pedagogical content knowledge in the subject of Geometry (Saputra et al., 2020). Video-based learning environments combining multimedia learning and anchored instruction support high school teachers' teaching in their classrooms. Teachers use vocabulary practices, and their students engage in the learning environments significantly more (Kennedy et al., 2017). As a result, we can claim that teachers need to be aware of such theory-proven methods to improve educational environments.

Mostly in the above-mentioned studies found in the literature anchored instruction-based materials were created to test the effectiveness of the materials in one-group experimental designs. Additionally, these studies recommended accessible anchored instruction-based videos which are delivered over the Internet. None of the studies have put an effort to understand whether pre-service teachers could create their materials based on anchored instruction theory. This theory would help them understand the true benefits from the materials that they may use in their teaching practices in their future practices. While anchored instruction related activities are helpful for students' meaningful learning, the use of anchored instruction causes a challenge for teachers as they cannot figure out how and where they should fit them into existing curricula (Hwang, et al., 2019). The present study aimed taking advantage of anchored instruction. Anchored instruction was not used as a teaching framework in the present study. Instead, it was used to help pre-service mathematics teachers use it as a framework to develop their technology-based learning tools. Three design principles of anchored instruction were utilized in this study (CTGV, 1990, p. 46). One of these principles is video-based format. The hypothesized benefits of this principle are more motivating, supporting complex comprehension and being especially helpful for poor readers. These elements are helpful for students' learning, problem solving and understanding. In this study, pre-service teachers created animations instead of video-based learning environments because animated objects are supportive for students' motivation, sense making, comprehension, attitudes and mathematics learning (Sato, 2016; Alexandron et al., 2018; Oktavianingtyas, 2018; Lubis, 2018; Dalacosta & Pavlatou, 2020). The second principle was narrative. Its hypothesized benefits are being easier to remember, more engaging and helping students notice the relationship between mathematics and everyday situation. Finally, the last principle was embedded data design principle. Its hypothesized benefits were allowing decision making, motivating to find and the relations of data with specific goals. As a result, it was expected that pre-service teachers can develop a deeper understanding of anchored instruction, its benefits on learning environments and technology use in education. Accordingly, a closer look is needed in teachers' technology knowledge in educational settings and developing technology materials in education.

2.2. Teachers' Technology Knowledge in Educational Settings

Teachers, who are the appliers of technology in education, should have necessary skills to be successful in integrating technology in their classes and need training in teacher education programs before starting their professions (Instefjord & Munthe, 2017). Specifically, teacher educators must be the role models for pre-service teachers so that they can learn integrating technology into educational settings (Tondeur et al., 2020). Pre-service teachers who are involved in technologically equipped classrooms activities increase their awareness of the advantages of technology in education (Lux & Lux, 2015). Moreover, classroom experiences are supportive for pre-service teachers' technology integration in their lesson plans (Mouza & Karchmer-Klein, 2013) However, how to teach with technology effectively is not well addressed in teacher education programs (Uerz et al., 2018). Mostly teachers have little understanding of effective technology use in their classrooms (Paratore, et al., 2016). At the first five years of their professions, teachers mostly use PowerPoint programs out of all technological tools (Tufte, 2003), which may be ineffective, have no effect on students learning, and even be harmful for students' academic performances if misused (Baker et al., 2018; León & Martínez, 2021). Yet, teacher education programs shape teachers' beliefs in technology integration, their knowledge about it and self- efficacy (Paratore et al., 2016). It is expected that teacher educators must be the role models using technology effectively in their classes (Tondeur et al., 2020). However, mostly instructors at teacher education institutions do not use technology in their classes, are not comfortable with it (Sprague, 2004; Onyia & Onyia, 2011; Voogt & McKenney, 2017; Martin, 2018) and struggling with the integration of technology (Voogt & McKenney, 2017).

Teachers confident with their technological skills believe the benefits of technology on students' learning (Saubern et al., 2020; Kıyıcı & Dikkartın Övez, 2021). Improving pre-service teachers' technology competence is necessary in this respect. In the literature, studies have different ways to do so. For example, Chien et al. (2012) in their study had pre-service teachers design online science courses. They observed that pre-service teachers have improved their level of technology competences. Moreover, pre-service teachers believed they felt readier for technology integration in education for their future professions. Teachers and teacher candidates' technological material creation was suggested to improve their teaching practices (Munday et al., 1991; Nurhayati, Suryani & Suharno, 2020). Moreover, technology competency is the most powerful predictor of teachers' technology integration in their classrooms (Agyei & Voogt, 2011). In Lee and Lee's (2014) study, pre-service teachers have created lesson plans that integrate instructional media and other technology tools. The authors measured pre-service teachers' confidence in technology integration in education. Results showed pre-service teachers' media development skills are highly positively correlated with their self-competence for technology integration. Additionally, only lesson planning was the significant predictor for technology integration in their future classrooms.

International Society for Technology Integration in Education (ISTE, 2008) standards for teachers advocate teachers must "design, develop and evaluate authentic learning experiences and assessments incorporating contemporary tools and resources to maximize content learning in context" (p.1). When teachers design technology-based activities for teaching, their attitude towards technology improves (Erümit, 2020). Thus, it is essential to teach teachers how to design, develop, and evaluate technology-based learning with meaningful contexts, which is supported by theories. In this study, pre-service mathematics teachers designed, developed, and evaluated technology-based learning supported by anchored instruction theory. They were the developers of mathematical materials based on anchored instruction theory.

2.3. Technology-Based Materials

Technology-based materials support students learning when effectively used (Paratore et al., 2016). A technological material combining text, images, video, sound supports learners learn better, and it transfers and transmits meaningful information (Mayer, 2007; Susanto & Riyanto, 2020). However, getting or preparing technology-based learning tools is not cheap and easy. Eight conditions affect the implementation of educational technology innovations (Ely, 1999). One is the availability of resources including software and media. This situation brings the idea of having teachers create their own educational applications in easier and cheaper way. Creating educational applications requires a deep programming knowledge. However, programming especially in the early stage is difficult to learn and students mostly have difficulty in understanding of the concepts (Kinnunen, & Malmi, 2008) and abstract concepts of the programming is not easily learned and embodied (Cam & Kiyici, 2022). Moreover, it takes a lot of time and patience to gain such knowledge to be able to create technology-based applications.

In the literature, visual programming tools such as Scratch, Alice, Blocky Games and Greenfoot were found to be beneficial tools when used as an introduction to programming for users (Noone & Mooney, 2018). These programming tools are free, and users can create their animations and games easily with these tools without having a deep programming knowledge. After using such programming tools, learners' programming self-efficacy becomes higher. Different from Alice and Greenfoot, Scratch has 2D images rather than 3Ds as in Alice. Additionally, different from other two programming tools, images could be either drawn or imported and more different types of projects can be created with Scratch (Maloney et al., 2010). The pre-service teachers used Scratch programming tool to create technology-based materials in the present study. Scratch has texts, images, animation, and audio recording features (Pinto & Escudeiro, 2014). With these features, programming commands are dragged and dropped to create multimedia-learning environments (Nikou & Economides, 2014; Resnick et al., 2009). These features of Scratch make it easier to learn programming through which games, stories, cartoons, and simulations can be created (Ouahbi et al. 2015). Since all the commands are visual and easy to use, age and background in programming don't matter (Marcelino et al., 2018). Users' creativity (Ouahbi et al., 2015; Pinto & Escudeiro, 2014), collaborative learning ability (Nikou & Economides, 2014) and problem-solving ability (Shin & Park, 2014) can also be improved with this programming tool. In this study, this visual programming tool was used by the pre-service teachers to create technology-based mathematics learning materials. However, these materials should fulfill some essentials to be beneficial for students learning.

Pre-service teachers' technology-based instructional material design activities improves their technology understanding and attitudes toward technology in educational settings (Chien et al. 2012; Lee & Lee, 2014; Erümit, 2020; Tondeur et al. 2020). However, such endeavor is not enough because pedagogical use of technology in educational settings is required (Sprague, 2004; Chien et al., 2012) since all the educational media is not helpful. It was claimed that an educational media presenting instruction should apply domain knowledge, evaluation, and conceptual theory to be successful (Sangsawang, 2015). To take the most advantage of technology in educational settings, Design-Based Research Collective (2003) advocates designing technological learning environments based on proven theoretical methods and suggest that anchored instruction supported learning designs are helpful for students. They advocate "the design of innovations enables us to create learning conditions that learning theory suggests are productive..." (p. 5), and add that Jasper series, an Anchored Instruction example, test context-based learning close to students' experiences supporting metacognition. In the literature too, designing teaching material with anchored instruction was proven to be valid and these materials improve students' critical thinking (Susanto & Lestari, 2020).

In this study, pre-service mathematics teachers created anchored instruction theory-based learning environments using a visual programming tool. They used an authentic context, revealed their designing process based on anchored instruction theory and evaluated this process. Instead of using readily available technological tools in their profession, they learned designing technological tools in an authentic context. Marshall & Rossman, (1995) states "The participant's perspective on the phenomenon of the interest should unfold as the participant views it, not as the researcher views it" (p.80). Because the participants' views are valuable and important, the purpose here is to reveal their perspectives about designing educational technology tool in an authentic context. Accordingly, it was aimed to reveal pre-service mathematics teachers' perspectives when they designed an educational tool, technology-based mathematics learning platforms in this study, based on anchored instruction theory.

Previous studies mostly used cases to teach concepts in the anchored instruction framework. Studies having pre-service teachers design anchored instruction materials are very limited. Only one study by Abbas (2008) had pre-service teachers prepare anchor videos to teach science and measured their perceptions about anchored instruction model. Their materials were videos as opposed to animations created by pre-service teachers in this study. This study is unique in having pre-service teachers design technology-based mathematics materials, animations, based on anchored instruction. Moreover, this study reports the analysis of their material creation process in anchored instruction framework. It was expected that creating their materials based on anchored instruction help them get better understanding of the theory itself and future classroom activities supported by the theory. They were expected to increase their beliefs in technology and learn how to support student learning with technology. As Design-Based Research Collective (2003) advocates, creating learning environments which are suggested by a learning theory yields productive results. As a result, it was expected that pre-service teachers would learn designing theory-based productive learning environments. In this regard, the research question was "What are pre-service mathematics teachers' design approaches of technology-based mathematics materials based on anchored instruction theory?"

3. Methodology

3.1. Participants and Procedure

52 pre-service mathematics teachers participated in this study. They were in their senior years at a college of education in a public university in Turkey. At the beginning, the pre-service teachers went through a 14-week learning period. In the first ten weeks, the pre-service teachers learned how to integrate technology in mathematics classes and some challenges they might face during technology integration. They learned mathematics education related technological applications and designed technology integrated mathematics lesson plans. For the last four weeks, they learned a block-based visual programming and designed several small projects, in which they applied what they learned during this period: scene changing, animating, inserting sounds, and providing interaction with users etc. A social networking group was created on a social media platform to communicate outside class. It was used to share their weekly assignments, final project ideas and to make comments to each other's work.

Upon the completion of learning period, they designed technology-based mathematics learning platforms in pairs based on anchored instruction theory (see Figures). For this, they wrote their stories first, in which mathematics word problems, hints and necessary feedback were embedded. They received feedback on their stories until the stories satisfactorily represented anchored instruction. They then designed their projects with their stories. The characters, scenes, problem-answer conversations in their stories were all used in their projects on the blocked-based visual programming tool. Six groups of students were selected for the purpose of this study with a purposive sampling method. The selection was made based on applying all the necessary requirements in good (*n*=2), average (*n*=2) or poor level (*n*=2) in their projects. The requirements were specified as followings: workability, interactivity, narration, completeness and representing anchored instruction's above-mentioned principles. Points were given for each requirement such as three points for good, two points for average, and one point for poor projects. As a result of the grading, the groups of students with whom the interview were conducted were selected. The identities of pre-service teachers are not to be disclosed in this paper. Rather, they are named PT1, PT2, PT3, PT4, PT5 and PT6, each representing a group of two pre-service teachers, who voluntarily responded the interview questions in the study. During the interviews, notes were taken in written form and recorded by a tape recorder for data analysis.

3.2. Design and Materials

In a qualitative framework, a case study approach was used in this study. A case study allows deeply understanding of a phenomenon, and a theoretical framework becomes a scaffold and provide basis for qualitative research (Merriam, 2013). For these reasons, a theoretical framework, the anchored instruction, was utilized from the beginning to the end in a case study approach in this study. The pre-service teachers' design approaches were examined after they designed their mathematical materials based-on anchored instruction theory. They were also asked to use a social networking website to share their projects from the beginning to the end and make comment to each other's work. Their design approaches were unfolded from their experiences mirrored in the interviews. The pre-service teachers were interviewed based on semi-structured interview questions with 13 open-ended questions. For the appropriateness of this tool, an expert's view in the department of computer education was taken. The first 10 questions were created based on anchored instruction's three design principles and their hypothesized benefits (see Table 1). These principles were video-based format, embedded data design and narrative format principles. Instead of the video-based format as a medium type, the pre-service teachers created animated learning environments. For this format, the questions were related to their approaches for motivating students, helping students comprehend their stories, and helping poor readers understand the story flow. For the narration format, the questions were related to making the stories understandable (i.e., to support remembering), connecting mathematics to everyday life, and the story characters' support for problem solving. For the embedded data design, the questions were related to their approaches for making problems recognizable in the story, designing their projects and stories to support problem recognition, creating a problem-solving environment, their precautions in case students cannot solve problems, and the feedback support. The last three questions were based on their experiences while designing their materials and their thoughts about such learning environments: difficulties they had while designing, positive and negative sides of such learning environments, and contribution of the process to their future profession. It took more than an hour to complete the interviews.

3.3. Data Analysis

The pre-service teachers' responses to the interview questions were tape-recorded and during the same time notes were taken. The voice records and notes were then written on paper sheets and coded by a single coder twice in a three-month time interval. The codes were then analyzed with a descriptive analysis under the themes in the anchored instruction framework (see Table 1). The themes were animation (as a replacement of video-based format), narration and embedded data. For the pre-service teachers' experiences, the themes were difficulties, negative and positive sides of designing, and contribution of the process. The codes were created deductively under these themes from the interviews. There was 81.2% intra-rater consistency between coding.

Table 1.

Three design principles and their hypothesized benefits of anchored instruction (CTGV, 1997, p.46)

Video-based format	A. More motivating B. Easier to search C. Supports complex comprehension D. Especially helpful for poor reader yet it can also support reading
Narrative with realistic problems	A. Easier to remember B. More engaging C. Primes students to notice the relevance of mathematics and reasoning for everyday events
Embedded Data Design	A. Permits reasoned decision making B. Motivating to find C. Puts students on an "even keel" with respect to relevant knowledge D. Clarifies how relevance of data depends on specific goals

4. Results

4.1. Pre-Service Teachers' Design Approaches Based on Anchored Instruction Framework

The pre-service teachers' answers to the first ten interview questions were divided into three themes under anchored instruction framework: Animation, narration, and embedded data. In the animation theme the categories were motivating, problem comprehension, and supporting poor readers. In the narration theme the categories were understandable, real-life connection, real life situations and character support. Lastly in the embedded-data theme the categories were problem recognition, animation vs. story for problem recognition, supporting and feedback support. The categories were determined based on the suggested benefits of the three above-mentioned design principles of anchored instruction theory.

Animation Theme

Table 2.

Pre-service teachers' approaches to catch attention

Animation (Theme) Motivating (Category)			
Codes	*f*	*%*	*PT #*
Voiceover	6	19.35	PT1, PT2, PT3, PT4, PT5, PT6
Animated characters	6	19.35	PT1, PT2, PT3, PT4, PT5, PT6
Background images	5	16.13	PT1, PT2, PT3, PT5, PT6
Narrated question-feedback	4	12.9	PT1, PT2, PT4, PT6
Scene switch	4	12.9	PT1, PT2, PT3, PT4
Question-related visuals	3	9.68	PT2, PT3, PT4
Music	1	3.23	PT6
Vivid colors	1	3.23	PT2
Speech balloons	1	3.23	PT4
Total	31	100	

Pre-service teachers' approaches to catch *students' attention* to their projects varied from using voiceover, animated character, background images, narrated question- feedback, scene switch, question-related visuals, music, vivid colors to speech balloons. Some of their comments were as followings:

> *"Voiceover makes animation even more catchy"* (PT6). *"We made the characters' motions eye-catching"* (PT5). *"The visuals in the story setting are supportive and may catch students' attention"* (PT2). *"We wanted students to actively participate to our material. For that, we used visual characters with audio"* (PT4).

Table 3.

Pre-service teachers' approaches to help students comprehend problems

Animation (Theme) Problem comprehension (Category)			
Codes	*f*	%	*PT #*
Voice + Speech balloons (text)	5	22.72	PT1, PT2, PT3, PT4, PT5
Dialog problems	4	18.18	PT1, PT2, PT4, PT6
Daily life	4	18.18	PT1, PT2, PT3, PT6
Visual support	4	18.18	PT1, PT2, PT3, PT5
Holds	3	13.63	PT2, PT4, PT6
Animating	2	9.09	PT1, PT6
Total	22	100	

Pre-service teachers' statements indicated that they supported *students' problem comprehension* by using speech balloons with voice, dialogue type problems, daily life, visual support, holds, and animating. Some of their comments were as followings:

> *"We used text and voice features in the project to support students' problem understanding"* (PT4) *"We gave the problems as dialogues and expected that students would interpret them"* (PT2). *"We made sure each number and symbol are associated to the real life"* (PT3). *"We asked a ticket related problem, created a ticket-seller character and had him ask the problem. At that moment, teacher walked towards him that is an eye-catching instance"* (PT1)

Table 4.

Pre-service teachers' approaches to support poor readers

Animation (Theme) Supporting Poor Readers (Category)			
Codes	*f*	%	*PT #*
Holds	6	25	PT1, PT2, PT3, PT4, PT5, PT6
Voiceover + Text	6	25	PT1, PT2, PT3, PT4, PT5, PT6
Standby time	6	25	PT1, PT2, PT3, PT4, PT5, PT6
Short texts	4	16.67	PT3, PT4, PT5, PT6
Background-problem Compatibility	2	8.33	PT2, PT3
Total	24	100	

Pre-service teachers stated that they paid attention to holds, voiceover and text, standby time, short texts, and background-problem compatibility to *support poor readers*. Some of their comments are below:

> *"We had holds within sentences so that students would have time to think, have an idea and make sense"* (PT6) *"We gave texts with voices. Thus, slow or poor readers could make it"* (PT5). *"We cut long sentences into short pieces in speech balloons and created easy, understandable sentences"* (PT4).

Narration Theme

Table 5.

Pre-service teachers' approaches to make their stories understandable

Narration (Theme) Understandable (Category)			
Codes	*f*	%	*PT #*
Daily life	5	22.77	PT1, PT2, PT3, PT4, PT6
Plain language	4	22.22	PT1, PT4, PT5, PT6
Ordinary things	3	16.66	PT2, PT3, PT6
Conversation	2	11.11	PT1, PT3
Tale	1	5.55	PT5
Level-appropriate	1	5.55	PT4
Introduction	1	5.55	PT5
Language rules	1	5.55	PT6
Total	18	100	

Pre-service teachers said when they designed their projects they paid attention to daily life, plain language, ordinary things, conversation, tale, level-appropriateness, introduction, and language rules to *support remembering*. Some of their comments are below:

> *"We paid attention to wording. That is, not to make kids confused, we avoided verbalism and used explanatory and plain sentences"* (PT5). *"We considered using circumstances, words and objects students are familiar with. So that they would connect those to what they already know"* (PT3). *"To make our story understandable, we gave it in conversation format"* (PT1). *"We paid attention to the language rules, expressed the story with more clear sentences"* (PT6).

Table 6.

Pre-service teachers' approaches to make real life connections

Narration (Theme) Real life connection (Category)			
Codes	***f***	*%*	***PT #***
Ordinary cases	5	22.72	PT1, PT2, PT3, PT4, PT6
Daily life problems	5	22.72	PT1, PT2, PT3, PT4, PT6
Ordinary problems	3	13.63	PT1, PT4, PT6
Case related problems	3	13.63	PT5, PT6
Internalizing	2	9.09	PT1, PT2
Real life objects	2	9.09	PT5, PT6
Total	22	100	

Pre-service teachers' approaches to *make real life connections* to the problems in their stories are as followings: ordinary cases, daily life problems, ordinary problems, case related problems, internalizing, and real-life objects. Some of their comments are below:

> *"We selected appropriate problems for students' level. The problems were from scenes or scenarios students would've seen before. All the problems we have are associated with real life"* (PT3) *"We specifically selected the problems within the ordinary problems that would be encountered in life. Because complicated problems may distract students' attention"* (PT4) *"Our problems were suitable to the plot and the natural structure of the story. So, we gave the message that mathematics is everywhere"* (PT5) *"We paid attention to a natural story, because (in real life) things are not planned. We thought they would understand better if they internalize things"* (PT2)

Table 7.

Pre-service teachers' approaches using real life situations as a basis for problem solving

Narration (Theme) Real life situations (Category)			
Codes	*f*	*%*	*PT #*
Ordinary situations	4	23.52	PT1, PT2, PT3, PT4, PT6
Story related problems	4	23.52	PT1, PT2, PT5, PT6
Connected problems	3	17.64	PT1, PT2, PT5
Role model	3	17.64	PT2, PT3, PT6
Daily life problems	2	11.76	PT1, PT4
Ordinary family	1	5.88	PT4
Total	17	100	

Pre-service teachers' interviews revealed that they used ordinary situations, story related problems, connected problems, role model, daily life problems and an ordinary family in their narrations to *use real life situations* as a basis for students' problem solving. Some of their comments are as follows:

> *"We produced problems where they may occur and students may experience"* (PT6) *"Essentially, when we created our story, we based the problems on real life. Story represented daily life and an ordinary day. Thus, all problems were produced like that"* (PT1) *"We continued on daily, connected, related (problems) with the examples they may see on streets"* (PT2) *"She (the character) do not get integers. Student may put himself in her shoes. I am having difficulty in integers too, he may think"* (PT3)

Table 8.

Pre-service teachers' approaches using characters to support students' problem solving

Narration (Theme) Character support (Category)			
Codes	*f*	*%*	*PT #*
Solution giver	5	31.25	PT1, PT2, PT3, PT4, PT6
Feedback	4	25	PT1, PT2, PT5, PT6
Problem asker	4	25	PT1, PT2, PT4, PT6
Character doing wrong	2	12.5	PT3, PT6
Helper	1	6.25	PT5
Total	16	100	

Pre-service teachers said they *used characters* as solution giver, feedback giver, problem asker, the ones doing wrong and helper. Some of the comments are given below:

> *"Having the characters solve problems will be beneficial for students to see how to solve the problems"* (PT2) *"If student gives incorrect answer, the character gives feedback and says its incorrect and then explains correct solution"* (PT1) *"Character is doing mistakes, then we ask students to check these mistakes. They will put themselves in the characters' shoes"* (PT6) *"Some characters in the story help the main character. That will make students develop positive feelings. If they feel positively, they may want to solve problems"* (PT5).

Table 9.

Pre-service teachers' approaches to make problems recognizable for students

Embedded data (Theme) Problem recognition (Category)			
Codes	*f*	*%*	*PT #*
Voice-over	3	17.64	PT2, PT4, PT6
Ask and wait block	2	11.76	PT1, PT6
Time period	2	11.76	PT2, PT3
Question sentence	2	11.76	PT1, PT4
Visuals	2	11.76	PT2, PT3
Answer box	2	11.76	PT1, PT4
Verbal expressions	2	11.76	PT2, PT4
Help	1	5.88	PT5
Talking animals	1	5.88	PT5
Total	22	100	

Embedded Data Theme

Interviews with the pre-service teachers revealed that they used the followings to help students *recognize problems*: Voice-over, ask and wait block, time period, question sentence, visuals, answer box, verbal expressions, help and talking animals. Some the comments from the interview are as followings:

> *"Because voice-over is a stimulant, students might take the main character's help request: could you please help me?"* (PT4) *"By putting time period, students may have enough time to read the problems"* (PT3) *"Problems were given as question sentences during characters' conversations"* (PT1) *"For problems to be recognized, we used verbal reactions the characters make. Such as when they see numbers, one of the characters reacts as if she is surprised"* (PT2)

Table 9a.

Pre-service teachers' way of using Scratch and their stories for students to recognize problems

Embedded data (Theme) Problem recognition animation vs. story (Category)			
Codes	*f*	*%*	*PT #*
Voice-over in animation	3	27.27	PT2, PT4, PT5
Problems in story	2	18.18	PT1, PT3
Visuals in animation	2	18.18	PT1, PT2
Feedback in animation	1	9.09	PT1
Muting in animation	1	9.09	PT3
Stimulants in animation	1	9.09	PT4
Ask and wait in animation	1	9.09	PT6
Total	11	100	

Pre-service teachers' approaches to *use visual programming and the story for students to recognize problems* are voice-over, problems in story, visuals, feedback, muting, stimulants and ask and wait code. Some of the comments are

> *"With voice-over we showed that the main character is sad. She has happy voice, if students find the correct answer"* (PT5) *"Specifically, we wrote our story with daily life problems. Thanks to the program, we converted them from abstract to concrete"* (PT3) *"We can see if students get a question wrong because animation helps seeing individual process. We can't give feedback based on student's mistake with story only" (PT1). "Using ask and wait code was effective. It was important for students to be activated"* (PT6)

Table 10.

Pre-service teachers' approaches to create problem-solving environment

Embedded data (Theme) Problem solving context (Category)			
Codes	*f*	*%*	*PT #*
Scene visual	3	27.27	PT1, PT2, PT3
Problem situation	2	18.18	PT1, PT2
Voice-over	2	18.18	PT4, PT6
Interesting story	1	9.09	PT5
Conversation flow	1	9.09	PT1
Help request	1	9.09	PT4
Problem scenes	1	9.09	PT3
Total	11	100	

Pre-service teachers' interviews showed that they used the followings to create *problem-solving context*: Scene visual, problem situation, voice-over, interesting story, conversation flow, help request and problem scenes. Some of their comments are

> *"For each problem, necessary problem scene picture was given as a problem situation"* (PT1) *"Characters solve problems where the story takes place. When characters encounter with a problem, they try to solve it where problem occurs"* (PT2). *"Our story has an intriguing plot. For it to be continued, students are expected to solve problems. Problem solving context is a part of the story and story continues with correct answers to the problems"* (PT5) *"For every different type of problem, we had different scenes so that students wouldn't get bored"* (PT3).

Table 10a.

Pre-service teachers' approach to support students in case they cannot solve problems

Embedded data (Theme) Supporting (Category)			
Codes	*f*	*%*	*PT #*
Solution	6	40	PT1, PT2, PT3, PT4, PT5, PT6
Feedback	5	33.33	PT1, PT2, PT3, PT4, PT6
Re-ask question	2	13.33	PT1, PT5
Voice-over	1	6.66	PT2
Motivate	1	6.66	PT4
Total	15	100	

Pre-service teachers' methods to have students *solve problems precisely* were to provide solution, feedback, re-asking question, voice-over and motivating. Some of their comments are

> *"When a question is solved wrong, we said you did wrong and then showed him how he is supposed to solve it. We asked him to check his solution"* (PT6) *"In case they can't solve problems we give feedback about the answer and how to solve the problems. This is the case after each answer they give"* (PT2). *"For a question answered wrong, our program asks it again and waits. There comes a text on screen saying, "Your answer is wrong, do it again""* (PT1) *"For students to solve problems we motivated them by saying "I wish you could solve the problem; it would be fun!"* (PT4).

Table 11.

Pre-service teachers' approach to support students to take advantage of feedbacks

Embedded data (Theme) Feedback support (Category)			
Codes	*f*	*%*	*PT #*
Persuasive text	5	35.71	PT1, PT2, PT3, PT4, PT5
Characters	3	21.42	PT1, PT2, PT6
Voice	2	14.28	PT2, PT3
Solution	2	14.28	PT1, PT6
Hint	1	7.14	PT4
Animation flow	1	7.14	PT2
Total	14	100	

Pre-service teachers' approach to help students *take advantage of the feedbacks* was to use persuasive text, characters, voice, solution, hint, and animation flow. Some of their comments are

> *"In animation, in case students give wrong answer, we used sentences such as "think again" to give feedback and to have students go for correct solution"* (PT1) *"We gave the feedback with voice. We gave the necessary feedback for wrong and right answers"* (PT3) *"We provide hint such as "we have to do subtraction, don't we?" Expected him to say yes or no"* (PT4) *"Story flow is not continued unless students see feedbacks. For the animation to be continued, students need to learn, read and listen to the feedbacks"* (PT2)

4.2. Pre-Service Teachers' Experiences/Thoughts while Designing Their Learning Environments: Difficulties, Positive and Negative Sides, and Contributions to the Future Career

a. Difficulties. Pre-service teachers were asked about the *difficulties* they had during their animation building process. Their responses were summarized as a concept map below:

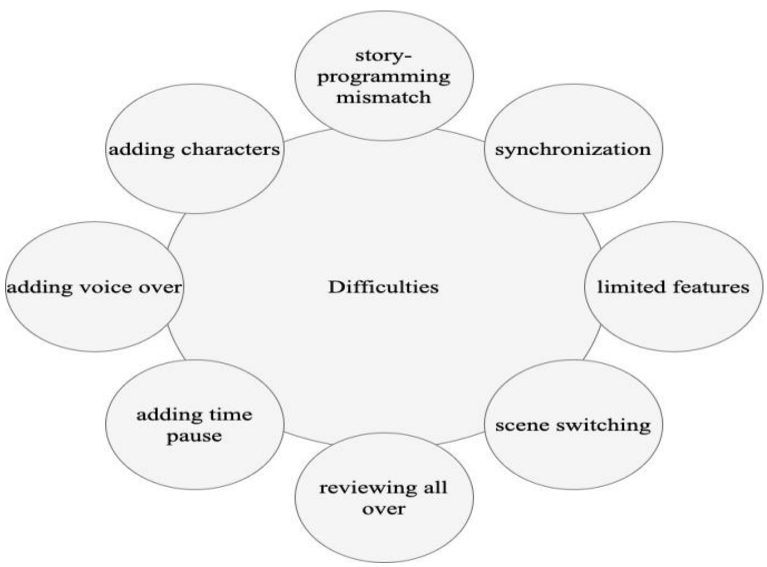

Fig. 1. Difficulties of design process

Mostly the difficulties were switching scenes, setting characters' position and movement, reflecting their stories into coding because of limited features of the block-based visual programming tool. Moreover, they said adding time pauses for voice, providing feedback and talks were the problems. They stated watching the animation repeatedly to see if what they coded was working all right was an issue for them. Some of their comments are below:

> *"While we wanted to correct an issue with the program or check the flow, we had to watch it over and over every single time. This situation caused us to lose time, was a tiring activity and thus created a negative situation"* (PT1). *"We placed nearly all events, characters' movements and talks one after another. Since we added the sounds lastly, there was a mess in timing with the flow"* (PT5).

b. Positive and negative sides. Pre-service teachers were also asked what they think about the positive and negative sides of presenting mathematical problems in this kind of learning environment. Their thoughts about the positive sides were organized as a concept map below:

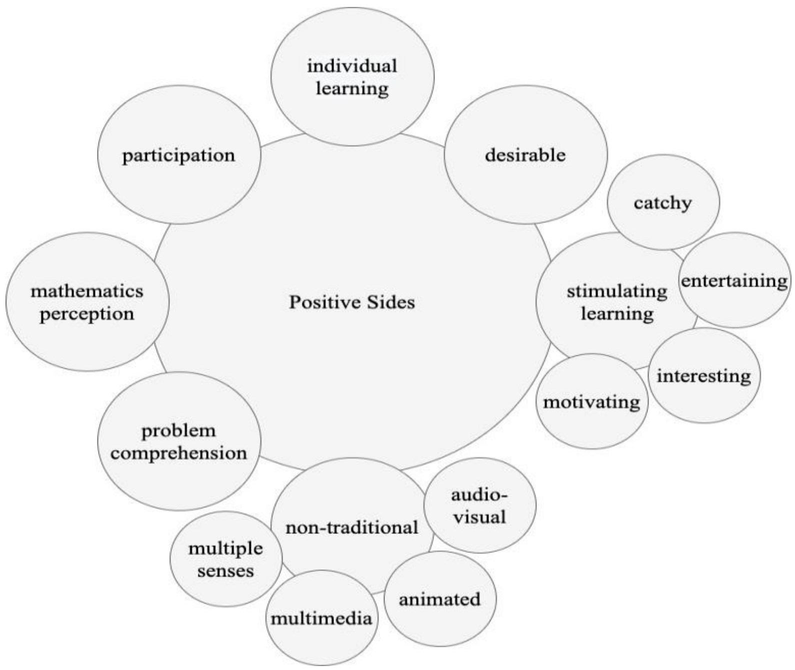

Fig. 2. Positive sides of the learning environment

They stated that it is a non-traditional method with multimedia learning features that may address students' multiple senses. Audio-visual support may catch students' attention. Cartoons and animations in a learning environment may be catchy for students since kids already like cartoons and animations. This learning environment might be stimulating since it might motivate and entertain students and catch their attention. Moreover, students might internalize what they learn, find it interesting since it might intrigue students. Additionally, individual learning as all in computer-based learning environments might be supported with such learning atmosphere and student participation could be increased in learning. Students' problem comprehension and as a result their problem solving could be improved. They also think that students' mathematical perception could be improved. Some of their comments are below:

> *"In traditional learning environments, there is one-way communication. Here we take advantage of visual and audial memory, multiple intelligence and learning by doing. It is a contemporary approach"* (PT2). *"First of all, it is eye-catching. It is going to be different from traditional methods. It is very appropriate for motivating and intriguing"* (PT4).

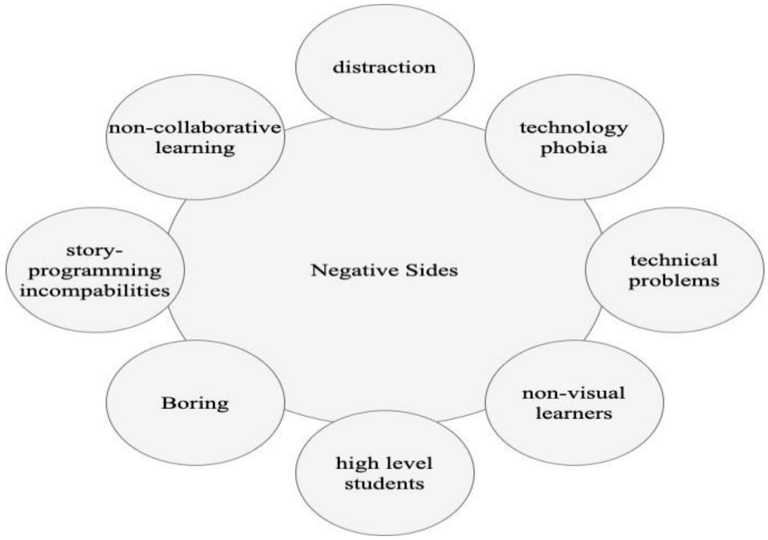

Fig. 3. Negative sides of the learning environment

As negative sides they said such learning environment might not be beneficial for those with technology phobia. If such environment is used for cooperative learning, providing feedback could be difficult and high-level students may get bored. They mentioned some of the story and programming incompatibilities because of limited features. They believe this learning environment would be meaningless for those who are non-visual learners. Some of their comments are:

> *"There could be some problems during implementation because of some technological issues, for example a power cut or lack of computers…"* (PT1) *"Only one negative side of such learning environments might be that it could be waste of time for smart students"* (PT5).

c. Contributions. Pre-service teachers were asked whether they think visual programming could contribute to their material design in future. Their answers were mostly yes. It is because it saves time, has advantage of reusability, appropriate to technology age, and supports teaching and learning. It is a non-traditional method and makes abstract mathematical concepts concrete. Some of their comments are:

> *"It contributes to material design. We can help students grasp knowledge with visual support. It has advantage of making abstract concepts concrete thanks to visual features"* (PT3). *"It can be reused over and over which is not the case for concrete materials. It is appropriate for the technology-age we are in"* (PT6)

Their thoughts about the contributions of the learning process were organized as a concept map below:

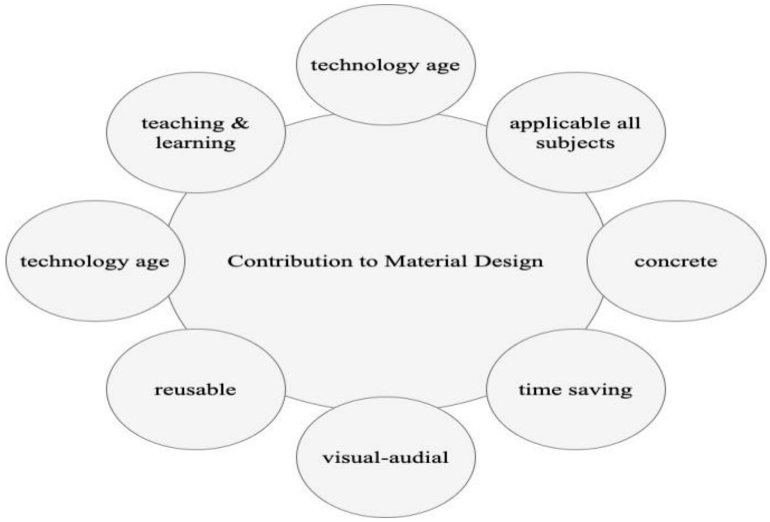

Fig. 4. Contribution of the learning process to material design

5. Discussions

In this section, pre-service teachers' views about the process are discussed under Animation, Narration and Embedded Data Design themes in relation with the related literature. These themes were determined from the Anchored Instruction's design principles, which were used in this study. A descriptive analysis was used under these themes. Moreover, pre-service teachers' thoughts about the positive and negative sides of the environment, their difficulties while designing and contribution of the process are discussed.

5.1. Theme1: Animation (As a Replacement of Video-Based Design)

Video-based format in Anchored Instruction have some hypothesized benefits: Being more motivating, supporting comprehension, easier to search and helping poor readers. This study used animated learning environment as a visual and dynamic platform replacing video-based format. Pre-service teachers were asked how they designed their animated learning environment to make it motivating, comprehensible and helping poor readers.

To make it motivating, pre-service teachers mostly reported they used animated characters, background images, narrated question and feedback, and scene switch. What they used least were music, vivid colors, question-related visuals, and speech balloons. To support users' problem comprehension, they reported they mostly used voice along with text presented in speech balloons and visual support to the problems. Problems were presented as dialogs between the characters and connected to the daily life. Using holds between sentences in the problems and animating characters during problem presentation was mentioned the least. To support poor readers' understanding of the story, they reported they mostly used holds between the sentences in the problems, voiceover support to the problem texts, pausing, and shortened texts. What they used least was background images supporting the problem scene so that poor readers could have a better sense of the problems.

In total, all six groups reported they used narration to support learners' motivation and learning. Narrating questions and feedbacks were the methods for four groups of pre-service teachers to motivate students for learning. For instance: "*We catch students' attention by narration. We did that because we didn't want students to get bored of reading the text"* (PT4). *"We gave the feedbacks narrated if they get the questions wrong"* (PT2). *"We narrated the questions because it makes them catchier"* (PT6).

In the literature, using personalized narration in on-screen text was found to be supportive for students' motivation (Park, 2015). Moreover, narrated feedback supports academic performance (Chiang & Vazquez, 2017) and narrated explanation improves students' understanding of new concepts (Hautala et al., 2018).

On the other hand, moving characters were found to support catching students' attention (Dalacosta et al., 2009; Dalacosta & Pavlatou, 2020). Parallel to this, all pre-service teachers reported they used animated characters. For instance: *"We chose the characters from animated ones to make the story entertaining"* (PT1).

AL-Ayash et al., (2016) report positive effects for the use of vivid colors on students' learning performance. One group, PT6, has reported using vivid colors in their projects to motivate students: *"We used vivid colors on the background images, such as red in the school".* Animated learning environments increase students' comprehension of difficult science concepts (Dalacosta et al., 2009). Additionally, text is better comprehended when narrated by an adult than text without narration (Yildirim et al., 2010a). In computer environments when on-screen text narrated, it is comprehended better (Park, 2015). Five groups of pre-service teachers reported they provided problems in text, which were presented in speech balloons, and narrated them. For example: *"We tried to present problems with visuals, speech balloons and voice to make the problems easily understandable"* (PT5).

Visuals help learners make sense of stories (Lubis, 2018) and supports comprehension of texts (Sato, 2016). Four groups of participants said they utilized visuals to support comprehension: For instance, "*We presented the problems as visuals, with which students would come across in daily life"* (PT2). *"Specifically, to help students comprehend number line problems, we used a building picture as a background image"* (PT3).

As a result, it can be concluded that pre-service teachers' methods to make their learning environments motivating, supporting comprehension, easier to search and helping poor readers were all supported in the literature. That is, their way of presenting problems in the animation is supported by the literature.

5.2. Theme 2: Narrative

Narrative format in anchored instruction has several hypothesized benefits: Being more engaging, easier to remember and relevance of mathematics and everyday events. Pre-service teachers' approaches to use these benefits were summarized below.

To support students remembering of their story, mostly pre-service teachers reported they used daily life situations, plain language, and ordinary things in the story. What was used least was a tale, an introduction to the characters at the beginning and paying attention to language rules. To show students that mathematics and everyday events are connected, mostly pre-service teachers reported they used ordinary cases, daily life problems, ordinary problems, and case related problems in their narratives. Real life objects such as nuts, trees, popcorns etc. in their narratives were used the least. Pre-service teachers were asked how they used real life situations as a basis to problems to support students' problem solving. They reported they mostly used ordinary situations, story related problems, problems that are connected and a role model in their story. The use of an ordinary family in their stories was mentioned least. Lastly, they mostly reported they used characters as a solution giver, feedback provider and a problem asker to support problem solving. The characters were used as those who are doing wrong in mathematics and a helper who is correcting the mistakes.

Mathematical knowledge given in classrooms is often detached from real life situations. Anderson, Reder and Simon (1996) claim "action is grounded in the concrete situation in which it occurs" (p.5). Thus, knowledge given in real-life settings is recommended. However, it is not always the case to bring students and real-life settings together. In such case, technology helps. Anchored instruction theory, which brings real life into classrooms via technology, advocates that learning occurs where it is to be used. Pre-service teachers' approaches to use real-life situations and ordinary objects for students' mathematics problem solving are in line with this idea. Some of their comments were as follows: *Everything in our story has examples from real life. Each child may go to a mall, a movie theater and may want to buy something and make calculations in daily conversations"* (PT6) *"Problems in our story were from those problems students would've experienced in daily life. This makes it easier for students to understand and answer the problems"* (PT2).

Pre-service teachers presented their stories in voice over form. They only presented mathematical word problems with voice and text. Yildirim et al. (2010) in their studies found that students' comprehension was better when they listen than when they read. In addition, pre-service teachers said they used a plain language to make the story and the problems understandable. For example, *"It was important to use plain and understandable language. We used daily Turkish instead of mathematical language".* (PT6)

Lockwood (2006) defines role models as ones providing a sample to success that one would demand. Pre-service teachers were asked how they managed the story characters that are helping students to solve problems. They stated they used the characters as solution providers or helpers, which were showing an achievement as Lockwood (2006) argues. *"Some characters in the story help the main character. That will make students develop positive feelings. If they feel positively, they may want to solve problems"* (PT5). *"Let's do it together, the character said. Then the problems were solved step by step…"* (PT4). That is, the characters were the ones who are good at mathematics problems might be a well of role models for students.

Meaningful contexts as stated in Anchored Instruction theory is helpful for learners to see knowledge as a tool to be used (CTGV, 1990). They are better helpful in providing word problems than the ones isolated (Bottge et al. 2015). As mathematics word problems are anchored to a story, solving them in the story is helpful in terms of seeing them meaningful (Leonard et al., 2005). While pre-service teachers used stories as a meaningful context for the problems, they had story related and connected problems. Their stories were of ordinary situations that anyone would encounter. *"We completely used ordinary situations based on two students going home from school"* (PT2). *"The problems we used in our story, which is narrating real life, support the story. Thus, the problems have become daily life problems"* (PT1). That is their story use was in line with the anchored instruction theory. As a result, what they have done would be beneficial for students' problem solving.

5.3. Theme 3: Embedded Data Design

Pre-service teachers' way of making problems in the story recognizable varied from using voice-over, ask and wait block, time periods after asking a problem, question sentences, visuals supporting the problem situation, answer box and verbal expressions. Characters' help requests and talking animals, who ask what is wrong with the character, was used only by one group. Pre-service teachers mostly supported students' problem recognition in their animations rather than in their stories. Voice-over, visual feedback, muting, stimulants, and ask and wait blocks were their way of supporting problem recognition. Having daily life problems in the story was only two groups' way of making problems recognizable. Scene visual, problem situation and voice-over were the mostly used features by pre-service teachers to create a problem-solving context. Creating an interesting story, conversation flow, main characters' help request, and problem scenes were the least used features.

It is proven that for difficult mathematics problems, problem solvers use visual strategies, such as drawing (Lowrie & Kay, 2001). However, only higher mathematical problem solvers have the visual imagery ability for problem solving (Van Garderen, 2006). It might be argued that supporting students with visual illustrations may help those who have limited visual imagery ability. However, illustrations representing problem situation may have no effect on students' word problem solving when presented next to a problem (Dewolf et al., 2015). Nevertheless, animations when used with narrations are found to be beneficial for students (Mayer & Anderson, 1991; Mayer, 2017). Pre-service teachers said they narrated their animations while using moving objects to support students' problem recognition and to create a problem-solving context. *"After a question is* *answered, students and teacher character move to the taxi. The taxi moves on, background images change, and movie theater scene comes up"* (PT1) *"If a student solves a problem wrong, voice-over goes like "I guess we did something wrong". If he solves it correct, voice-over goes like "good job". We expect student to solve all problems"* (PT4).

Moreover, their method to support students' problem recognition was to use features such as voice-over or feedback in their animations. For instance, pre-service teachers stated that they used feedback to support students' problem solving in case students cannot solve problems. The use of feedbacks supports students' mathematical problem solving when given immediately and in summative format specifically on computer-based learning environment (Fyfe & Rittle-Johnson, 2016). One example comment for this is: "*"For the wrong answers, the program allows students to think. In case answer is wrong we give feedback: "Your answer is wrong, let's listen to the teacher", and then the story continues"* (PT1). Their way to use feedback was generally to show the correct solution such as *"To help students see the feedback, we showed the correct solution for those who solved it correct or incorrect"* (PT6). However, only one group used hint-type feedback, which was shown to be the most effective type of feedback supporting students' mathematical problem solving (Bringula et al., 2017). *"We provide hint such as "we have to do subtraction, don't we?" Expected him to say yes or no"* (PT4).

The pre-service teachers were also asked how they provided the feedback support so that students may take the most benefit. Pre-service teachers stated they used the characters as a role model who is showing feedback. Role models demonstrating an achievement may lead to an inspiration for a learner to succeed (Lockwood, 2006). One example comment was: *"When we write a problem, we wrote it as if characters solve it correct"* (PT2). Thus, it can be concluded that their way of using feedback may yield a success for learners who use the projects pre-service teachers have created.

As a result, pre-service teachers' use of embedded data design is supported by the literature and in line with anchored instruction.

5.4. Thoughts about the Process

The Ministry of National Education of Turkey (MNE, 2018) requires teachers to be well skilled in technology that is to access, produce, evaluate, store, produce, interchange and present information. In supporting ISTE (2008) standards for teachers, this study had pre-service teachers design, develop, and evaluate an authentic learning experience. They have produced technology-based environment with a visual programming tool to teach mathematics. They were asked what they think about the process in general such as difficulties during the development of the projects, positive and negative sides of such problem-solving environments and contributions to their material design process, if any.

Designing online courses (Chien et al., 2012) or technological materials (Munday et al., 1991; Lee & Lee, 2014) were proven methods and an indicator showing that a teacher will integrate technology in his classrooms (Agyei & Voogt, 2011). Additionally, teachers' beliefs and attitudes toward technology are stated as the biggest reasons for their technology integration and knowledge about technology (Ertmer et al., 2012). Pre-service teachers mostly have positive reactions to the process in this study. They believe that as a non-traditional multimedia-learning environment, their projects would help students with their multiple senses. They are appropriate for students' interests, motivating, entertaining and thus they would make students like mathematics. They believe, if used as an individual learning environment, students would participate more in their learning as opposed to collaborative learning. Additionally, they believe this learning environment will be more beneficial for visual learners. They additionally stated they would use this kind of environment in the future for their material design. Instead of concrete materials, their projects would be used over and over in a convenient way. Such learning environments are teaching and learning supportive, helpful to make mathematics concrete and suitable for technology natives.

Block-based visual programming tools have limited features such as characters and scenes were stated as problems when reflecting their stories to this visual programming tool. Designing new projects could eliminate their personal difficulties such as inserting voice or providing feedback. These problems might be occurring because they have no programming background. For instance, they did not have to watch their animations repeatedly to correct an issue because the visual programming tool they used in fact allows monitoring only the codes they wish to monitor. With these results, we can conclude that pre-service teachers with such learning and designing activity could see the positive and negative sides of technology in education. Thus, they may develop an attitude towards technology integration in education. As a result, they may decide whether to use technology in their future profession.

6. Conclusion and Limitations

In this study, pre-service mathematics teachers had a meaningful experience in designing their own technology-based learning environments. They designed, developed, and evaluated technology-based learning environment they created. Their technology-based creation was based on the three design principles of anchored instruction theory. The results of this study showed that pre-service teachers can design technology-based learning environments, which is in line with related literature. Moreover, their design process is based on a proven theory, which is anchored instruction in this study. It can be claimed that they learned supporting students learning with a learning theory, using technology effectively in classroom settings, and designing technology-based environments which support students' learning.

Pre-service teachers' evaluation of the process was highly positive, and they developed a positive understanding of technology use in education. Moreover, their design approaches were supported by anchored instruction theory and took the advantage of the suggested benefits of the theory. As a result, their projects can support students learning. It was observed that they made use of the positive learning elements supported by technology-related literature. If teacher education programs guide pre-service teachers through designing such learning environments, the outcome would be beneficial for pre-service teachers to develop positive beliefs about technology based instructional design. Pre-service teachers' technology beliefs will affect their technology integration in their future classes. If teachers' technology beliefs can be improved, they can integrate technology in their future professions.

This study was limited to a small sample size of participants. However, the results are promising in that pre-service teachers' beliefs in technology increase, they can have theory-based design experiences and learn how to support students with technology. For these reasons these types of studies are worthy of further investigation. It is the limitation of this study that this study did not measure whether pre-service teachers have improved their technology competences. In this regard, future studies can measure pre-service teachers' technology competences with reliable questionnaires. Moreover, this study is limited to one block-based visual programming tool which doesn't have enough features to reflect project ideas. Different programming tools could be used, different design experiences could be provided, and results could be interpreted accordingly in the future studies.

References

Abbas, N. (2008, December). *Using anchored instruction to teach pre-service teachers to integrate technology into primary science education.* World Association of Lesson Studies Conference, Hong Kong. https://repository.nie.edu.sg/bitstream/10497/15448/1/WALS-2008_Noraini_a.pdf

AL-Ayash, A., Kane, R. T., Smith, D., & Green-Armytage, P. (2016). The influence of color on student emotion, heart rate, and performance in learning environments. *Color Research & Application*, *41*(2), 196-205. https://doi.org/10.1002/col.21949

Alexandron, G., Keinan, G., Levy, B., & Hershkovitz, S. (2018). Evaluating the effectiveness of animated cartoons in an intelligent math tutoring system using educational data mining. *Edmedia +Innovative Learning*, *2018*, 719-730. Waynesville, NC, USA.

Anderson, J. R., Reder, L. M., & Simon, H. A. (1996). Situated learning and education. *Educational Researcher*, *25*(4), 5-11.

Arah, A. S., Umar, I. Y., Rufai, A., Idris, A. M., Saidu, H. A, Elmahmud, M., & Mohammed, A. U. (2017). Effect of video based anchored instruction on students' achievement and retention in motor vehicle mechanics work in Abuja and Niger States, Nigeria. *ATBU Journal of Science, Technology and Education*, *5*(2), 91-99. http://repository.futminna.edu.ng:8080/jspui/handle/123456789/4353

Agyei, D. D., & Voogt, J. M. (2011). Exploring the potential of the will, skill, tool model in Ghana: Predicting prospective and practicing teachers' use of technology. *Computers & Education*, *56*(1), 91-100. https://doi.org/10.1016/j.compedu.2010.08.017

Baker, J. P., Goodboy, A. K., Bowman, N. D., & Wright, A. A. (2018). Does teaching with PowerPoint increase students' learning? A meta-analysis. *Computers & Education*, *126*, 376-387. https://doi.org/10.1016/j.compedu.2018.08.003

Bottge, B. A., Toland, M. D., Gassaway, L., Butler, M., Choo, S., Griffen, A. K., & Ma, X. (2015). Impact of enhanced anchored instruction in inclusive math classrooms. *Exceptional Children, 81*(2), 158-175. https://doi.org/10.1177/0014402914551742

Bringula, R., De Leon, J. S., Rayala, K. J., Pascual, B. A., & Sendino, K. (2017). Effects of different types of feedback of a mobile-assisted learning application and motivation towards mathematics learning on students' mathematics performance. *International Journal of Web Information Systems*, *13*(3), 241-259. https://doi.org/10.1108/IJWIS-03-2017-0017

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, *18* (1), 32-42.

Cam, E. & Kiyici, M. (2022). The impact of robotics assisted programming education on academic success, problem solving skills and motivation. *Journal of Educational Technology & Online Learning*, *5*(1), 47-65. https://doi.org/10.31681/jetol.1028825

Castillo, Wi L. (2020). Supporting mathematic achievement for students with learning disabilities through enhanced anchored instruction. *The STEAM Journal*, *4*(2). https://doi.org/10.5642/steam.20200402.18

Chen, M. (2019). The use of anchored instruction for Chinese speaking skills: A case study of travel agency staff. *The 14th UTCC national graduate research conference*. (pp. 92-99). Bangkok, Thailand: University of the Thai Chamber of Commerce.

Chiang, E. P., & Vazquez, J. J. (2017). The power of a simple verbal explanation: Evaluating the efficacy of narrated feedback. *International Review of Economics Education*, 25, 25-34. https://doi.org/10.1016/j.iree.2017.04.002

Chien, Y. T., Chang, C. Y., Yeh, T. K., & Chang, K. E. (2012). Engaging pre-service science teachers to act as active designers of technology integration: A MAGDAIRE framework. *Teaching and Teacher Education*, *28*(4), 578-588. https://doi.org/10.1016/j.tate.2011.12.005

Cognition and Technology Group at Vanderbilt (1990). Anchored instruction and its relationship to situated cognition. *Educational Researcher, 19* (6), 2-10.

Cognition and Technology Group at Vanderbilt (1997). *The jasper project: Lessons in curriculum, instruction, assessment, and professional development.* Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Dalacosta, K., Kamariotaki-Paparrigopoulou, M., Palyvos, J. A., & Spyrellis, N. (2009). Multimedia application with animated cartoons for teaching science in elementary education. *Computers & Education*, *52*(4), 741-748. https://doi.org/10.1016/j.compedu.2008.11.018

Dalacosta, K., & Pavlatou, E. A. (2020). Using cartoons agents and 3D visualizations based on HTML5 for improving learning in crystal structures in engineers. *Computer Applications in Engineering Education*, *28*(1), 5-16. https://doi.org/10.1002/cae.22169

Design-Based Research Collective (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, *32* (1), 5-8. https://doi.org/10.3102/0013189X032001005

Dewolf, T., Van Dooren, W., Hermens, F., & Verschaffel, L. (2015). Do students attend to representational illustrations of non-standard mathematical word problems, and, if so, how helpful are they? *Instructional Science*, *43*(1), 147-171. https://doi.org/10.1007/s11251-014-9332-7

Ely, D. P. (1999). Conditions that facilitate the implementation of educational technology innovations. *Educational Technology*, *39*(6), 23-27.

Erol, O., & Kurt, A. A. (2017). The effects of teaching programming with scratch on pre-service information technology teachers' motivation and achievement. *Computers in Human Behavior*, *77*, 11-18. https://doi.org/10.1016/j.chb.2017.08.017

Ertmer, P.A., Ottenbreit-Leftwich, A.T., Sadik, O., Sendurur, E. & Sendurur, P. (2012). Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education, 59*(2), 423-435. https://doi.org/10.1016/j.compedu.2012.02.001

Erümit, A. K. (2020). Effects of different teaching approaches on programming skills. *Education and Information Technologies*, *25*(2), 1013-1037. https://doi.org/10.1007/s10639-019-10010-8

Fyfe, E. R., & Rittle-Johnson, B. (2016). The benefits of computer-generated feedback for mathematics problem solving. *Journal of Experimental Child Psychology*, *147*, 140-151. https://doi.org/10.1016/j.jecp.2016.03.009

Hautala, J., Baker, D. L., Keurulainen, A., Ronimus, M., Richardson, U., & Cole, R. (2018). Early science learning with a virtual tutor through multimedia explanations and feedback on spoken questions. *Educational Technology Research and Development*, *66*(2), 403-428. https://doi.org/10.1007/s11423-017-9558-6

Hou, H. T., & Lin, Y. C. (2017). The development and evaluation of and educational game integrated with augmented reality and virtual laboratory for chemistry experiment learning. In *Advanced Applied Informatics (IIAI-AAI), 6th IIAI International Congress*, 1005-1006.

Hwang, J., Riccomini, P. J., Hwang, S. Y., & Morano, S. (2019). A systematic analysis of experimental studies targeting fractions for students with mathematics difficulties. *Learning Disabilities Research & Practice*, *34*(1), 47-61. https://doi.org/10.1111/ldrp.12187

Indriani, R. Y. (2020). Teaching reading narrative text through anchored instruction strategy to the eighth grade students of state junior high school 46 of palembang. *Esteem Journal of English Education Study Programme*, *3*(2), 128-139. https://doi.org/10.31851/esteem.v3i2.4815

Instefjord, E. J., & Munthe, E. (2017). Educating digitally competent teachers: A study of integration of professional digital competence in teacher education. *Teaching and teacher education*, *67*, 37-45. https://doi.org/10.1016/j.tate.2017.05.016

International Society for Technology Integration in Education (ISTE, 2008). *National Educational Technology Standards for Teachers.* Eugene, OR: ISTEs.

Kennedy, M. J., Hirsch, S. E., Rodgers, W. J., Bruce, A., & Lloyd, J. W. (2017). Supporting high school teachers' implementation of evidence-based classroom management practices. *Teaching and Teacher Education*, *63*, 47-57. http://dx.doi.org/10.1016/j.tate.2016.12.009

Kıyıcı, O. D. & Dikkartın Övez, F. T. (2021). Examination of technology acceptance and TPACK competencies of mathematics teachers who are involved in distance education practices during the pandemic process. *Journal of Educational Technology & Online Learning*, *4*(4), 805-821. https://doi.org/10.31681/jetol.1012204

Kinnunen, P., & Malmi, L. (2008). CS minors in a CS1 course. In *Proceedings of the fourth international workshop on computing education research, ICER*. 79-90. New York, USA.

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)?. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60-70.

León, S. P., & García-Martínez, I. (2021). Impact of the provision of PowerPoint slides on learning. *Computers & Education*, *173*, 104283. https://doi.org/10.1016/j.compedu.2021.104283

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, USA: Cambridge University Press.

Lee, Y., & Lee, J. (2014). Enhancing pre-service teachers' self-efficacy beliefs for technology integration through lesson planning practice. *Computers & Education*, *73*, 121-128. https://doi.org/10.1016/j.compedu.2014.01.001

Leonard, J., Davis, J. E., & Sidler, J. L. (2005). Cultural relevance and computer-assisted instruction. *Journal of Research on Technology in Education, 37* (3), 263-284. https://doi.org/10.1080/15391523.2005.10782437

Lockwood, P. (2006). "Someone like me can be successful": Do college students need same-gender role models? *Psychology of Women Quarterly*, *30*(1), 36-46. https://doi.org/10.1111/j.1471-6402.2006.00260.x

Lowrie, T., & Kay, R. (2001). Relationship between visual and nonvisual solution methods and difficulty in elementary mathematics. *The Journal of Educational Research*, *94*(4), 248-255. https://doi.org/10.1080/00220670109598758

Lubis, R. (2018). The progress of students reading comprehension through wordless picture books. *Advances in Language and Literary Studies*, *9*(1), 48-52. https://doi.org/10.7575/aiac.alls.v.9n.1p.48

Lux, N., & Lux, C. (2015). The influence of technology-rich early childhood field experiences on pre-service teachers. *Journal of Technology and Teacher Education, 23*(2), 213-240.

Magana, A. J., Falk, M. L., Vieira, C., & Reese, M. J. (2016). A case study of undergraduate engineering students' computational literacy and self-beliefs about computing in the context of authentic practices. *Computers in Human Behavior, 61,* 427-442. https://doi.org/10.1016/j.chb.2016.03.025

Malik, A., Dirgantara, Y., & Muhammad, N. (2021). The effect of anchored instruction models to enhance understanding of students related concept of vector. *Perspective, 65*(80), 95. https://doi.org/10.5220/0010025205900594

Maloney, J., Resnick, M., Rusk, N., Silverman, B., & Eastmond, E. (2010). The scratch programming language and environment. *ACM Transactions on Computing Education (TOCE)*, *10*(4), 16. http://doi.acm.org/10.1145/1868358.1868363.

Marcelino, M. J., Pessoa, T., Vieria, C., Salvador, T., & Mendes, A.J. (2018). Learning computational thinking and scratch at distance. *Computers in Human Behavior. 80*(2018), 470-477. https://doi.org/10.1016/j.chb.2017.09.025

Martin, B. (2018). Faculty technology beliefs and practices in teacher preparation through a TPaCK lens. *Education and Information Technologies, 23*(5), 1775-1788. https://doi.org/10.1007/s10639-017-9680-4

Mayer, R. E. (2007). Multimedia learning (2nd ed.). New York: Cambridge University Press. https://doi.org/10.1017/CBO9780511811678

Mayer, R. E. (2017). Using multimedia for e-learning. *Journal of Computer Assisted Learning*, *33*(5), 403-423. https://doi.org/10.1111/jcal.12197

Mayer, R. E., & Anderson, R. B. (1991). Animations need narrations: An experimental test of a dual-coding hypothesis. *Journal of Educational Psychology*, *83*(4), 484. https://doi.org/10.1037/0022-0663.83.4.484

Marshall, C., & Rossman, G. B. (1995). *Designing qualitative rese*arch (2nd ed.). Thousand Oaks, CA: Sage.

Ministry of National Education (2018). *Matematik dersi öğretim programı (İlkokul ve Ortaokul 1, 2, 3, 4, 5, 6, 7 ve 8. Sınıflar)*: Ankara, Turkey. Retrieved from http://mufredat.meb.gov.tr/Programlar.aspx

Miranda, H. P., & Russell, M. (2012). Understanding factors associated with teacher-directed student use of technology in elementary classrooms: A structural equation modeling approach. *British Journal of Educational Technology*, *43*(4), 652-666. https://doi.org/10.1111/j.1467-8535.2011.01228.x

Mouza, C., & Karchmer-Klein, R. (2013). Promoting and assessing pre-service teachers' technological pedagogical content knowledge (TPACK) in the context of case development. *Journal of Educational Computing Research*, *48*(2), 127-152. https://doi.org/10.2190/EC.48.2.b

Munday, R., Windham, R., & Stamper, J. (1991). Technology for learning: Are teachers being prepared? *Educational Technology*, *31*(3), 29–31. https://www.jstor.org/stable/44425762

Nikou, S. A., & Economides, A. A. (2014). Transition in student motivation during a scratch and an app inventor course. In *Global Engineering Education Conference (EDUCON), 2014 IEEE*, 1042-1045.

Nurhayati, S., Suryani, N. & Suharno. (2020). Need Analysis of Audio-Visual Media Development to Teach Science Materials for Young Learners. *Journal of Educational Technology & Online Learning, 3*(2), 152-167. https://doi.org/10.31681/jetol.672104

Noone, M., & Mooney, A. (2018). Visual and textual programming languages: a systematic review of the literature. *Journal of Computers in Education, 5*(2), 149-174. https://doi.org/10.1007/s40692-018-0101-5

Oktavianingtyas, E., Salama, F. S., Fatahillah, A., Monalisa, L. A., & Setiawan, T. B. (2018, November). Development 3D animated story as interactive learning media with lectora inspire and plotagon on direct and inverse proportion subject. In Journal of Physics: Conference Series. (Vol. 1108, No. 1, pp. 012111). IOP Publishing. https://doi.org/10.1088/1742-6596/1108/1/012111

Onyia, C. R., & Onyia, M. (2011). Faculty perception for technology integration in Nigeria university system: Implication for faculty quality curriculum design. *International Journal of Business and Social Science*, *2*(12), 81-92.

Ouahbi, I., Kaddari, F., Darhmaoui, H., Elachqar, A., & Lahmine, S. (2015). Learning basic programming concepts by creating games with scratch programming environment. *Procedia-Social and Behavioral Sciences*, *191*, 1479-1482. https://doi.org/10.1016/j.sbspro.2015.04.224

Paratore, J. R., O'Brien, L. M., Jiménez, L., Salinas, A., & Ly, C. (2016). Engaging preservice teachers in integrated study and use of educational media and technology in teaching reading. *Teaching and Teacher Education, 59,* 247-260. https://doi.org/10.1016/j.tate.2016.06.003

Park, S. (2015). The effects of social cue principles on cognitive load, situational interest, motivation, and achievement in pedagogical agent multimedia learning. *Journal of Educational Technology & Society*, *18*(4), 211-229. https://www.jstor.org/stable/jeductechsoci.18.4.211

Pinto, A., & Escudeiro, P. (2014). The use of Scratch for the development of 21st century learning skills in ICT. *In Information Systems and Technologies (CISTI), 2014 9th Iberian Conference on IEEE,* 1-4.

Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., Rosenbaum, E., Silver, J., Silverman, B. and Kafai, Y. (2009). Scratch: Programming for all. *Communications of the ACM*, *52*(11), 60-67. https://doi.org/10.1145/1592761.1592779

Sangsawang, T. (2015). Instructional design framework for educational media. *Procedia-Social and Behavioral Sciences, 176*, 65-80. https://doi.org/10.1016/j.sbspro.2015.01.445

Saputra, E., Ulya, K., Wahyuni, S., Rahmadhani, E., & Hakim, H. (2020). Media application in anchored instruction to support mathematics teachers' pedagogical content knowledge. In *Journal of Physics: Conference Series* (Vol. 1460, No. 1, p. 012042). IOP Publishing.

Sato, T. (2016). Could a multimodal dictionary serve as a learning tool? An examination of the impact of technologically enhanced visual glosses on L2 text comprehension. *The EuroCALL Review*, *24*(2), 3-12. https://doi.org/10.4995/eurocall.2016.5236

Saubern, R., Urbach, D., Koehler, M., & Phillips, M. (2020). Describing increasing proficiency in teachers' knowledge of the effective use of digital technology. *Computers & Education, 147,* 103784.

Sprague, D. (2004). Technology and teacher education: Are we talking to ourselves? *Contemporary Issues in Technology and Teacher Education*, *3*(4), 353-361.

Shin, S., & Park, P. (2014). A study on the effect affecting problem solving ability of primary students through the scratch programming. *Advanced Science and Technology Letters. 59*,117-120. https://doi.org/10.14257/astl.2014.59.27

Susanto, R., & Lestari, E., S. (2020). The effect of flipbook-based field teaching materials with anchored instruction model to improve students' critical thinking skills. *European Journal of Education Studies*, *7*(12), 642-652.

Susanto, R., & Riyanto. (2020). Development of Teaching Material of Sony Vegas Media Based with Anchored Instruction Models for Tennis Course in IKIP Budi Utomo Malang. *Proceeding International Conference on Science and Engineering, 3,* 623-627. https://doi.org/10.14421/icse.v3.576

Tufte, E. (2003). *PowerPoint is Evil*. Wired Magazine, September 10(11), 9-11. Retrieved from https://www.wired.com/2003/09/ppt2 on June 17th, 2020.

Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2020). Enhancing pre-service teachers' technological pedagogical content knowledge (TPACK): A mixed-method study. *Educational Technology Research and Development, 68(*1), 319-343. https://doi.org/10.1007/s11423-019-09692-1

Uerz, D., Volman, M., & Kral, M. (2018). Teacher educators' competences in fostering student teachers' proficiency in teaching and learning with technology: An overview of relevant research literature. *Teaching and Teacher Education*, *70*, 12-23. https://doi.org/10.1016/j.tate.2017.11.005

Van Garderen, D. (2006). Spatial visualization, visual imagery, and mathematical problem solving of students with varying abilities. *Journal of Learning Disabilities*, *39*(6), 496-506. https://doi.org/10.1177/00222194060390060201

Voogt, J., & McKenney, S. (2017). TPACK in teacher education: Are we preparing teachers to use technology for early literacy? *Technology, Pedagogy and Education, 26*(1), 69-83. https://doi.org/10.1080/1475939X.2016.1174730

Williams, S. M. (1992). Putting case-based instruction into context: Examples from legal and medical education. *Journal of the Learning Sciences*, *2*(4), 367-427. https://doi.org/10.1207/s15327809jls0204_2

Yildirim, K., Yildiz, M., Ates, S., & Rasinski, T. (2010). Fifth-grade Turkish elementary school students' listening and reading comprehension levels with regard to text types. *Educational Sciences: Theory and Practice*, *10*(2), 1879-1891.