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Digital Story-Based Problem Solving Applications: Preservice Primary Teachers' Experiences and Future Integration Plans

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Abstract: This case study investigates how preservice primary school teachers describe their experiences with digital story-based problem solving applications and their plans for the future integration of this technology into their teaching. Totally 113 preservice primary school teachers participated in the study. Data collection tools included a questionnaire with three open-ended questions and focus group interviews. The data were analyzed using content analysis by combining manifest and latent techniques. Most of the preservice primary teachers described positive experiences about digital story-based problem solving applications by emphasizing on that they contribute to both their own and their students' learning, development, and attitudes. Participants further described digital story (DS) integration as in line with behaviorist pedagogy. Study results revealed that most of the preservice primary school teachers planned to integrate DSs into their future classrooms for purposes such as capturing students' attention and reinforcing, rewarding, or supporting learning.

Introduction

Math education is of ever-growing global importance, but most children describe mathematics as boring and difficult (Sedighian & Sedighian, 1996). Sedghi, Arnett and Chalabi (2013) present the OECD's Program for International Student Assessment (PISA) results which show that unsurprisingly, children in many countries possess low level of math skills. What is the reason for this poor performance, despite the importance given to mathematics in curriculums, and what is the solution? Robin (2008) has emphasized digital storytelling as one way to improve student performance in Math. Likewise, Smith, Gerretson, Olkun, and Joutsenlahti (2010) have found out how math problems can include causal stories to enhance student understanding. However, Sadik (2008) states that digital storytelling is not beneficial for teaching mathematics or science. Meanwhile, Muir-Herzig (2004) and Judson (2006) have claimed that very few teachers use technology during teaching. Kurt's study results (2013) support this claim, revealing that teachers generally use technology for non-educational purposes like instruction preparation and student homework or assessment. Usta and Korkmaz's (2010) study show that preservice teachers need to be provided instruction on integrating technology into their classrooms. On this point, Draper, O'Brien, and Christie (2004) and Orungbemi (2009) have also stressed the importance of teacher education and its role in preparing future teachers to tackle problems in the classroom. Similarly, there are more studies which investigate the technology integration skills of preservice teachers by highlighting the importance of providing experiences that positively affect their future technology integration decisions (Ertmer et al., 2001; Bhattacherjee & Premkumar, 2004). Clearly, preservice teachers should know how to integrate technology while teaching mathematics with a special focus on problem solving. The current study explores how a group of preservice primary teachers describe their experiences with digital story-based problem solving applications as technological tools as well as their future integration plans for these tools.

Literature Review

Technology-Supported Math Problem Solving and Digital Stories (DSs)

Problem solving is the cornerstone of both school and real-life mathematics. Mathematics curriculums have received strong focus in many countries such as Australia, the UK, the United States, and Singapore (Stacey, 2005; Ministry of National Education [MoNE], 2009). National Council of Teachers of Mathematics (NCTM) standards (2000) emphasize that without the ability to solve problems, the powers of other mathematical ideas and skills become severely limited. The Turkish primary school mathematics curriculum recommends that problem solving should be an integral part of mathematics lessons and activities (MoNE, 2009). Thus, teaching and learning problem solving skills is an important aspect of mathematics education in all grades of schools in many countries.

The problem-solving process consists of four sequential phases: understanding the problem, devising a plan, carrying out the plan, and looking back (Cathcart et al., 2003; Souviney, 1994). Understanding the problem is crucial for finding an exact solution and involves grasping the situation, determining facts, and establishing the intended goal. After understanding the problem, a plan is devised and then must be carefully carried out. Finally, the solution is assessed and computations are checked. This process requires applying more than just mathematical skills and concepts. Despite the importance of problem solving for primary students (Bernardo, 1999; Verschaffel et al., 1999) and preservice primary teachers (Taplin, 1998), they still frequently encounter difficulties during problem solving activities. Students struggle to decode mathematical problem structures embedded in text (Bernardo, 1999) and have misconceptions about numbers and arithmetic operations (Verschaffel et al., 1999). In their study, Contreras and Martínez-Cruz (2003) found that majority of preservice primary teachers (about 91%) proposes incorrect solutions to the problems asked.

The NCTM (2000) has asserted that appropriate and responsible use of technology enables students to learn mathematics more deeply, so teachers must make prudent decisions about when and how to use it. Moreover, many studies on the math problem solving process have been supported with technology. Most of this research has investigated the impact of technology on problem solving performance and preservice teachers' views about technological problem solving applications. For example, Kale and Whitehouse (2012) have examined preservice teachers' problem solving skills through the use of an online video case study and found out that participants had a high level of skill to generate pedagogical and content solutions. Daher (2009) investigated preservice teachers' perceptions regarding the roles and functions of applets in a problem solving context as well as their use in solving mathematical problems. Results showed that most participants felt applets were not indispensable for math problem solving activities but played a variety of roles, such as facilitating and clarifying mathematical problem statements and solutions in addition to entertaining students.

Like applets, DSs are one of the computer-based tools that can be used for problem solving activities. DSs are creative movies resulting from the combination of personal narrative and multimedia (Banaszewski, 2005). This process is also called digital storytelling by many scholars such as Banaszewski (2005), Robin (2008), and Yuksel (2011). Although the nature of DSs makes them suitable for mathematical problem solving activities, Robin (2008) and Sadik (2008) have observed that few studies have been conducted which apply DSs to teaching mathematics or science. A true research gap exists related to the use of DSs in mathematics activities such as problem solving applications, which may be explained by perceptions that DSs are more appropriate for social fields such as art, language, or history (Sadik, 2008).

Theoretical Background: Behaviorism

Behaviorism is one of the theories of learning. “Cause” and “effect” have been associated with the theory which emphasizes that “cause” is a “change in an independent variable” and an “effect” is a “change in a dependent variable.” The old “cause-and-effect connection” becomes a functional relation (Skinner, 1953). In behaviorist theory, there are some other important factors apart from cause and effect. Wollard (2010) indicates that appropriate behaviors include making progress, solving problems, achieving outcomes, supporting others, being on-task, being attentive to the instruction given by the teacher and so on. Ertmer and Timothy (1993) describes learning from the behaviorist perspectives by implying that “behaviorism equates learning with changes in either the form or frequency of observable performance” (p.54).

In this study, DSs were used in line with behaviorist pedagogy in that math problems were asked through DSs to primary school pre-service teachers. Ertmer and Timothy (1993) give an example of using flashcard material which includes the question of the equation “2+4=?” and state that learners give answer of “6”. This process is using flashcards in line with behaviorist pedagogy (Ertmer & Timothy, 1993). This study includes use of DSs in similar manners in that learners know the problem types and strategies to solve, DSs just includes the math problems.

Need for the Current Study

2012 PISA results show that countries such as UK, France, Greece, Turkey, and the Russian Federation do not have a good math performance (Sedghi et al., 2013). According to Sedighian and Sedighian (1996), children describe mathematics as boring and difficult. Robin (2008) has claimed that digital storytelling is one way to enhance students’ success in math, but there is limited research conducted to understand the benefits of digital stories to teach math. Mishra, Koehler, and Kereluik (2009) have looked at the history of educational technology which includes many studies showing technology did not effect on students’ learning. Moreover, they have pointed out the importance of appropriate integration of technology to instruction for success (Mishra, Koehler, & Kereluik, 2009). Ertmer (2005) categorizes obstacles that prevent the appropriate integration of technology into two levels of barriers as first order barriers (lack of or inadequate equipment, time, training, or support) and second order barriers (related to teachers’ beliefs about learning and teaching). Second order barriers are more difficult to overcome (Ertmer, 2005). However, a large number of studies accept teachers as primary actors who facilitate technology integration (Mishra & Koehler, 2006; Ertmer, 1999; Ertmer, Gopalakrishnan, & Ross, 2000; Usta & Korkmaz, 2010). For that reason, Ertmer et al. (2001) has emphasized the importance of providing technology integration experiences to preservice teachers to increase their competency and confidence. Moreover, Bhattacherjee and Premkumar (2004) have claimed that such experiences may affect preservice teachers' future technology integration decisions.

Previous research drives the current study. Despite strong claims regarding the relationship between preservice teachers' experiences with technology at university and their future decisions about technology use, few studies have investigated preservice teachers' descriptions of these experiences or their technology integration plans. Although this study is not experimental and does not investigate whether the preservice primary teachers' experiences affected their future decisions, it reveals what the preservice primary teachers identified as important for technology integration decision. Moreover, this study has a value because it also shows how preservice primary teachers' experiences of using DSs for problem-solving application have a role in their future integration decisions. It may also provide a base for studies seeking to develop scales related to experience and future technology integration decisions or to conduct experimental research investigating the effects of such experiences on those decisions.

Research Questions

1. How do preservice primary school teachers describe their digital story-based problem solving experiences?
    - In terms of their problem solving processes?
    - In terms of students' problem solving processes?
2. How do preservice primary school teachers describe their planned future integration of digital story-based problem solving applications?
    - How would they integrate digital story-based problem solving applications into their teaching practices?
    - Which math topics would they select for integrating digital story-based problem solving applications into their teaching practices?

Method

In this case study research, data were collected using a two-step process. First, a questionnaire asking three open-ended questions was administered to participants in four cases; and then, focus group interviews were conducted. According to Patton (1987), case studies are particularly useful when one needs to understand a particular situation in great depth (Patton, 1987), while Yin (2003) has highlighted how well case studies answer "how" and "why" questions. This case study investigates how primary school teachers describe their digital story-based problem solving application experiences and the reasons behind these descriptions.

Setting and Participants

The research was conducted in the spring semester of the 2013–2014 academic years. Participants included 113 volunteer preservice primary school teachers aged 21 to 22; all participants were in their sixth undergraduate semester. Of the participants, 65 were female and 48 were male. Students were enrolled in Mathematics Teaching II, a three-credit course that introduces constructing and solving math problems, and Computer course which they learnt basic computer use. The Mathematics Teaching II course was offered in four sections, and each section included about 30 students. All preservice primary school teachers completed the open-ended questionnaire, and 7–10 participants from each section were interviewed through focus groups (FG_1, FG_2, FG_3, and FG_4). Interviewees were selected according to their problem solving performance and willingness to participate. Focus group interviews provided in-depth information about the preservice primary school teachers' experiences using digital story-based problem solving applications.

Before the study, participants were asked about their previous problem solving experience using technology. According to the results, 26 participants had experience with certain technologies, 6 had stated having experience by not naming the technology they used, 69 had no experience and 12 preservice teachers did not answer the question. The technologies mentioned included PowerPoint (n = 4), the Internet (n = 8), a projector and a computer (n = 4), a calculator (n = 8), videos (n = 1), and pictures/images (n = 1). The preservice primary school teachers who had no experience problem solving with technology pointed to insufficient infrastructure in their schools. Focus group results supported the open-ended questionnaire results in that most preservice primary school teachers reported not using technology during problem solving activities in class.

Data Collection and Instruments

In order to investigate preservice teachers' experiences with digital story-based problem solving applications, eight DSs related to operations with fractions were developed by the researchers. During development, two experts were consulted, one from mathematics and one from instructional technology. Both experts' interests included technology-supported math learning and digital storytelling in math education.

During data collection, participants watched DSs on a projection screen, stopping to solve written problems after each one. Next, a three-question open-ended questionnaire asked them to describe their experiences with the digital story-based problem solving applications and their future integration plans for that technology. This instrument was developed by the researchers and checked by an external expert. The external expert has been working as academician at the Curriculum and Instruction Program of the Educational Sciences Department for 25 years. Her interest areas include technology-supported learning, instructional technology, and lifelong learning. Free writing on a theme (Kratochvilova, 2010) was incorporated as indicated in the study of Arnon and Reichel (2007), wherein open-ended questionnaires enabled respondents to reflect spontaneously and authentically. Participants were given 45 minutes to complete the questionnaire. Finally, focus group interviews were conducted with four groups. Interviews lasted about 30–35 minutes per group and were video recorded. In the findings section, focus group comments are presented to support participant experiences.

The second data collection instrument was an interview form developed by the researchers, which included seven questions related to the preservice teachers' experiences with the digital story-based problem solving activities. These questions were also controlled by an external expert. The first interview question asked about participants' previous problem solving experiences, and the last interview question asked for suggestions about the activities. The other five interview questions addressed how participants described their digital story-based problem solving experience by focusing on the effects of this technology on their problem solving processes and performances. Moreover, these interview questions examined how the preservice teachers would integrate this technology into their future teaching. (see two screenshots of one of DSs used in the study in Figure 1).

The DS includes story about one of the mathematics teachers' holiday travel to the city in the second photo (the total road is 420 km). The teacher gaves two breaks on the road (one is on $\frac{2}{3}$ of the total road, second is on $\frac{1}{2}$ of the remain road), and the DS includes problem about the remain road after the second break of the teacher.

Figure 1. Two screenshots and short version of one of DSs used in the study.

Data Analysis

The data collected through the open-ended questionnaire were analyzed using manifest and latent content analysis techniques, as Berg (2001) has stated that these techniques can be used together. He described manifest content as physically present and countable elements and latent content as "an interpretive reading of the symbolism underlying the physical data" (p. 242). In this study, themes emerged as an interpretive reading of the symbolism underlying the physical data; in other words, the preservice teachers' statements were categorized, and then themes and subcategories were counted according to frequencies. The data analysis process included four steps: (a) all responses were listed, (b) written responses were independently classified according to similar categories and subcategories by two researchers, (c) categories and subcategories were determined gradually, and (d) reorganized (Miles & Huberman, 1994; Merriam, 1998).The frequencies of the sub-categories were given in parentheses as f, and the teachers' views were given using " " in paragraphs after the categories. To calculate inter-rater reliability, Miles and Huberman's (1994) formula was applied. Moreover, focus group interviews were transcribed and coded independently by the researchers using the three-phase classification system of Miles and Huberman (1994): data reduction, data display, and conclusion drawing/verification. In the data reduction phase, after tape recordings were transcribed, the researchers read the transcript, selected the data, and coded them according to the theoretical framework and patterns that emerged. During data display, a table was created to present verbal information obtained from participants. In the conclusion drawing and verification phase, themes were interpreted and compared, and participant opinions were examined.

Validity and Reliability Issues

To increase the trustworthiness and validity of the study, as suggested by Lincoln and Guba (1985), member checks and a conformability audit were conducted. Furthermore, the researchers asked for the opinion of a colleague who was blinded to the data and unbiased regarding the code list and research findings. In order to examine inter-rater reliability and increase the reliability of the qualitative results, another colleague with a mathematics and computer education background independently classified the interview data. Miles and Huberman's (1994) formula was applied to calculate inter-rater reliability and it was found to be 81% (79% for question 1, 77% for question 2, and 91% for question 3). Similarly, focus group interviews were analyzed by the researchers independently, and inter-coder reliability was found to be .86. Then, the researchers discussed the differences in categories and reached consensus on a final theme list. A pilot study also contributed to the validity and reliability of the questionnaire and interview questions.

Ethical Issues

At the beginning of the study, all participants were informed about the research aim and signed a consent form to signify their voluntary participation. Since one of the researchers was also the instructor, students might have feared retaliation for negative comments. Therefore, they were assigned pseudonyms and the data were analyzed after the semester concluded.

Results

Descriptions about the Use of Digital Story-Based Math Problem Solving Applications

The codes for this topic consisted of four themes: preservice teachers' development in terms of problem solving process, students' development in terms of problem solving process, no contribution, and suggestions. For personal contributions, the preservice teachers mostly described their experiences in terms of the advantages that DSs provided. Some preservice teachers expressed not one but many advantages, disadvantages, or suggestions in terms of their own or their students' problem solving processes (see Figure 2).

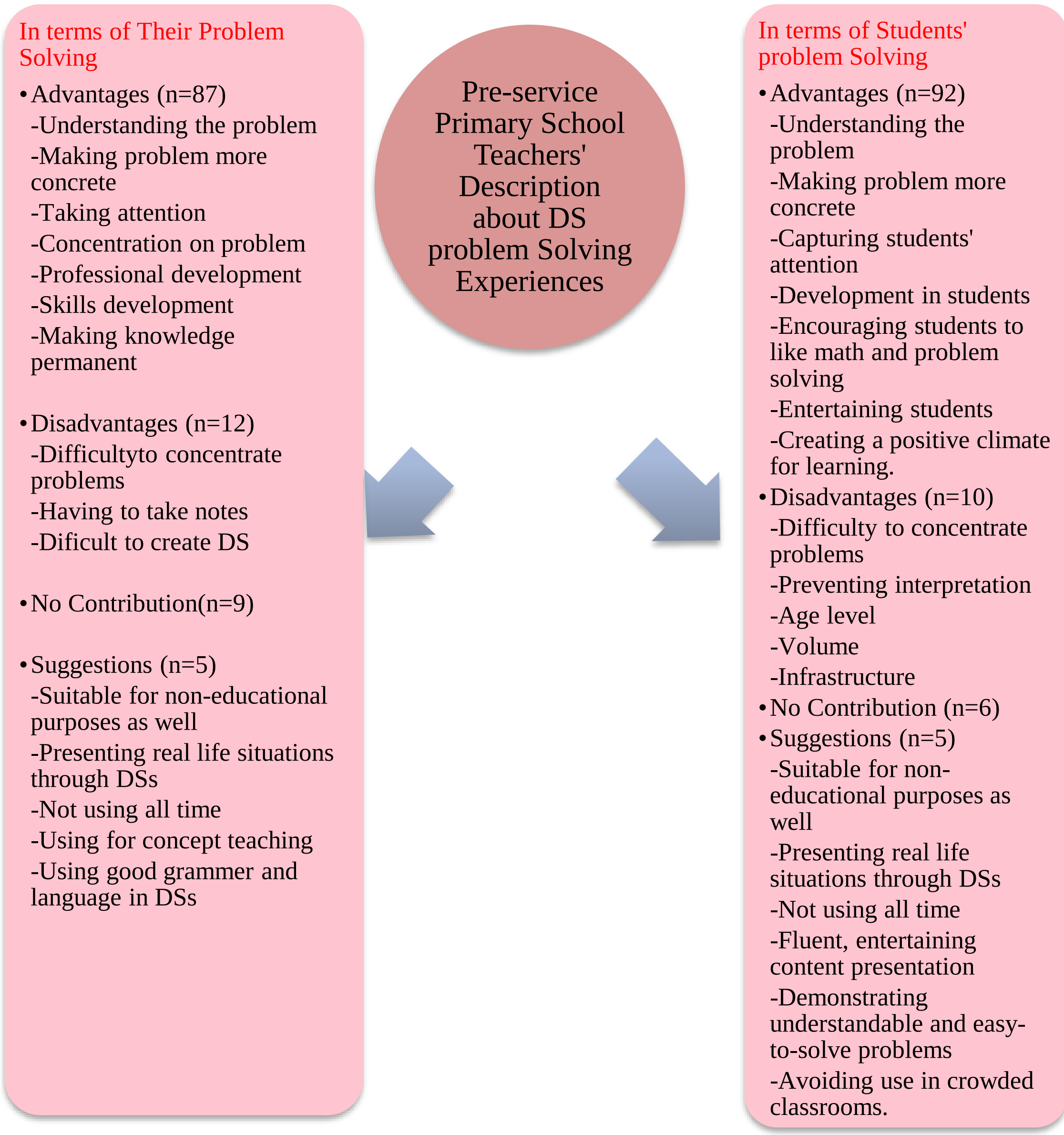

Figure 2. Pre-service primary school teachers' descriptions about the use of Digital Story-Based math problem solving

As seen from Figure 2, most of the preservice primary teachers (n = 87) highlighted the advantages of these tools. However, 12 out of 113 preservice teachers pointed to the disadvantages of using DSs during problem solving, while nine stated that DSs had no effect. Five of the preservice teachers gave suggestions on the use of DSs during problem solving activities.

Most of the preservice primary school teachers (f = 46) stated that DSs contributed to understanding problems better since they created a link between problems and the real world. Moreover, the visual and audio components made the stories appealing, further contributing to understanding. DSs enhanced concentration during problem solving activities (f = 22) in addition to capturing attention (f = 23). An important number of preservice teachers also pointed out that DSs helped them to visualize problems (f = 15) and made knowledge permanent (f = 15), and many indicated that DSs could contribute to professional (f = 22) and skill development (f = 16). Participants felt that DSs could help them create a good class climate, making teaching easier and more effective. They stated that DS problem solving activities provided a new, creative, and entertaining method that encouraged students to like math. The preservice primary school teachers identified several skills that were developed by DSs, such as thinking, understanding, attention, and problem solving. A few preservice teachers indicated that DSs enhanced their desire to solve problems (f = 3). Moreover, one preservice primary school teacher explained how DSs prevented him from misreading questions, and another observed that the DS provided new activity ideas.

The focus group interview results supported the open-ended questionnaire results. Themes that emerged as a result of data analysis included understanding the problem, entertaining students, increasing attention, solving problems easily, keeping interest, stirring imagination, enhancing the desire to solve problems, and learning a new method. Moreover, the preservice primary school teachers stated that the biases they had about using the technology were eliminated during the problem solving activities. Some comments from the group interviews related to participants' DS-based problem solving experiences are as follows:

> *FG_1: DSs helped us to understand problems. We experienced the problems. It made the course more fun. It increased our attention and interest. We have the opportunity to watch again.*
>
> *FG_2: The problems are story based; for that reason, my interest grew towards digital story-based problem solving applications. I wanted to solve problems and it amazed me. Problem situation became clearer. Some examples were from daily life applications, and they helped us to understand. We can watch again. Problem solving application became enjoyable.*
>
> *FG_3: Visual and auditory elements drew our attention. During digital storytelling applications, there was an extra information; it gave us general cultural knowledge. The pictures explained everything, so we solved problems easily. We could imagine the events in problem situations. Because it appeals to the senses, it helped to understand more easily and to keep in mind. Those stories motivated me. My curiosity was aroused. The examples in the stories were from daily life, so it helped us to draw attention.*
>
> *FG_4: I felt myself in the problem because of the visual and auditory elements. I solved the problems very willingly. I was interested in the problems. I saw my bias decrease because the math did not consist only of numbers. I could make connections between daily life and mathematics. I realized mathematical problems can be presented not only in a written form but also can be presented through technology-based elements.*

The focus interview results showed that the problem solving process of the primary school teachers followed four sequential phases: understanding the problem, devising a plan, carrying out the plan, and looking back (Cathcart, Pothier, & Vance, 2003; Souviney, 1994). The groups made the following comments related to these process steps:

- ***Understanding the problem***

  FG_1: We found what was given and what we had to find. I understood well and I acted out the problems in my mind easily.

FG_2: I understood problems having visual and auditory elements well. Moreover, we could easily understand the problem, and it made problems more concrete.
FG_3: The visual and auditory elements in the stories make the problems more clear.
FG_4: I both listened and watched; for that reason, I understood well and could interpret easily.

- ***Devising a plan***
  FG_1: When I understood well, I could determine the solution strategy. Digital story-based problem solving applications helped us to determine the strategy.
  FG_3: We could figure out how to solve problems (in other words, which operations we could use) while watching DSs.
  FG_4: It helped to determine the path to the solution.
- ***Carrying out the plan***
  FG_1: Being more visual lead me to carry out the plan. I solved it in a very short time.
  FG_2: I solved it very quickly. I realized the problem context well and solved it.
  FG_3: Since DSs contributed to the first two processes of problem solving, as understanding a problem and devising a plan, it contributed to carrying out the plan.
  FG_4: In fact, while watching the stories, we solved the problems.
- ***Looking back***
  FG_2: I realized my mistakes when I watched a second time.

The open-ended questionnaire results also revealed some disadvantages of using DSs in problem solving, according to 12 preservice primary school teachers. For example, DSs prevented them from fully interpreting problems since they were distracted by taking notes (f = 5). One preservice teacher indicated that the DS led her to an incorrect solution, while another felt creating a DS was difficult. As seen from Figure 2, nine preservice primary school teachers believed DSs provided no contributions to their problem solving process. Moreover, five participants offered suggestions about the use of DSs during problem solving activities for: (a) non-educational purposes, (b) presenting real life situations, (c) displaying good grammar and language, and (d) concept teaching. According to the teachers, DSs could be created for non-educational purposes such as birthdays, focusing on real life situations and clear and understandable grammar for maximum benefit (see Figure 2).

The themes and categories that emerged regarding preservice primary school teachers' perceptions of the use of DSs in terms of students' problem solving processes were also positive as shown in Figure 2. Most preservice teachers (n = 92) expressed advantages such as improving understanding of the problem, making problems more concrete and knowledge more permanent, capturing students' attention, increasing concentration, enhancing student development, encouraging students to like math and problem solving, entertaining students, and creating a positive climate for learning, problem solving, and taking notes. On the other hand, a few preservice primary school teachers (n = 10) listed the following disadvantages of DSs with regard to students' problem solving processes: issues with concentration, interpretation problems, age level appropriateness, volume, and infrastructure (See Figure 2). Six preservice teachers felt the DSs provided no contribution to students' problem solving processes, while five made additional suggestions about DS use.

According to the preservice primary school teachers, DSs can help students to understand a problem by presenting relevant, real life situations. The students can easily imagine the problem, making their knowledge more concrete and increasing their concentration. The preservice teachers emphasized how students paid attention because the stories were visually attractive and entertaining, so the students liked the math and problem solving activities and gained more permanent knowledge. In this type of learning climate, students are likely to solve problems more easily, more quickly, and with greater motivation. An important number of preservice teachers (n=24) pointed out that DSs may develop students' skills in mental processing, logical thinking, concentration, listening, creativity, problem solving, mathematics, information connection, visual intelligence, and interpretation.

The codes that emerged as a result of focus group interview analysis were concentration on the problem, capturing students' attention, and prompting students to like math, all of which were consistent with the open-ended questionnaire results. Two quotes from the focus groups support these themes:

FG_2: It takes students' attention, provides concentration.

FG_4: It develops positive attitudes of students towards mathematics.

On the other hand, as shown in Figure 2, 10 out of 113 preservice primary school teachers expressed disadvantages of DSs in terms of students' problem solving processes. One example was related to concentration, since DSs presented more details about the problems. According to three preservice teachers, DSs may hinder the interpretation of problems, and the age level of students may prevent them from understanding problems in a DS. One preservice teacher further expresses that not all schools possess the required technology to benefit from DSs, while another emphasizes how some students may have difficulty hearing the DS, causing additional issues during problem solving activities.

The suggestions for using DSs in problem solving activities that were offered by the preservice teachers in the focus groups paralleled those from the open-ended questionnaire (see Figure 2): (a) for non-educational purposes, (b) for presenting real life situations, (c) for exhibiting proper grammar and language, (d) for teaching concepts, (e) for assigning text-based problems to students, (f) for fluent, entertaining content presentation, (g) for demonstrating understandable and easy-to-solve problems, and (h) for avoiding use in crowded classrooms. One preservice teacher described how she also gave text-based versions of the problems to young and deaf students to enhance their preparedness and development. Overall, the teachers indicated that non-educational language of DSs should be clear, and problems should be easy to solve.

Themes that emerged as a result of focus group interview analysis were (a) entertaining and fluent content presentation, (b) understandable and easy-to-solve problems, (c) introducing DSs as early as first grade, (d) sharing content through CDs and the Internet, and (e) using DSs as measurement tools. The preservice primary school teachers state that attractive photos and music in DSs may contribute to entertainment levels. Moreover, they pay attention to the use of understandable grammar and language to help learners to understand problems more clearly. Relevant comments from focus group interviews are as follows:

FG_1: It can be given as a project to the students. It should be applied from very early years, from first grades for example. It can be also used as an alternative assessment method. We can make a website and share our digital stories through the website.

FG_2: There should be more attractive photos like characters from cartoons. Digital stories can be recorded on CDs, and besides course books, those CDs

can be given to the students as a learning material. The stories that are created should be shared with other students and be accessible to all students.
FG$_3$: It is a good vehicle to spread constructivist approach. We can use a DS as a measurement tool. We can prepare exams using DSs. The photos and music may be more attractive.
FG$_4$: Some sentences can be shown in the digital stories for understanding problems more clearly. Digital stories can be used as a measurement tool.

Descriptions of Future Integrations of Digital Story-Based Problem Solving Applications

The second open-ended question was asked whether the preservice primary school teachers intended to use DSs during problem solving activities in their future classrooms. The codes that emerged under this title consisted of two main themes: (a) integration of digital story-based problem solving applications into teaching practices and (b) math topics. As seen Table 1, four themed responses emerged: yes, partial use, depending on conditions, and no. Out of 113 preservice teachers, 99 stated they would use DSs during problem solving activities, while a few explained they would use these materials sometimes (n = 6) or depending on certain conditions (n = 5). The smallest number (n = 3) would not use DSs during problem solving activities.

Themes	Sub-categories	Frequency
Categories and sub-categories ➢ Yes (n=99)	* In terms of students' success	
	✓ Taking students attention	29
	✓ Providing learning	15
	✓ Proving students concentrate on lessons	13
	✓ Providing permanent knowledge	10
	✓ Understanding problems	14
	✓ Relating problem with real life	5
	✓ Supporting problem solving	2
	✓ Helping students to imagine problems in mind	1
	- Visuals	2
	✓ In terms of creating positive affective attitudes Positive attitudes towards problem solving	9
	✓ positive attitudes towards math	6
	✓ Positive attitudes toward attending lessons	1
	* In terms of students' skills development	
	✓ Enhancing imagination	2
	✓ Enhancing interpretation	1
	✓ Development in long term memory	1
	✓ Providing logical thinking	1
	* In terms of teachers	
	✓ Making problem solving entertaining and attractive	22
	- Visuals	
	- Having stories	2
	✓ Making lesson attractive	11
	✓ Providing a different atmosphere for students (a new	21
	method or attractive for them)	9
	✓ Providing classroom management	
	✓ Making teaching easy and efficient	3
	✓ Making easy to follow students' performance	3

	✓ Assessing different students' skills ✓ Providing better learning	2 1 1
	∗ In terms of instructional material ✓ Having affective sides ✓ Suitable to constructivist philosophy	 1 1
Categories and sub-categories ➤ Partly Use (n=6)	∗ Taking students attention ∗ Motivating students ∗ Making students like problem solving ∗ Timing ✓ Not every time ✓ Not using when having time limitation	1 1 2 3 1
Categories and sub-categories ➤ Depending Conditions (n=5)	∗ If the class size is appropriate ∗ If stories are attractive ∗ If students preparedness is suitable ∗ If teaching through DS in real class is successful	1 1 2 1
Categories and sub-categories ➤ No (n=3)	∗ Belief about how problems are solved ∗ DS killing curiosity because they include everything ∗ Not paying attention to important points ∗ Causing students lost concentration ∗ Not concrete ∗ Students' difference	2 1 1 2 1 1

Table 1. Primary Preservice Teachers' Future Technology Integration Decisions and Reasons

For the preservice teachers who did intend to use DSs during problem solving activities, five categories of responses emerged in terms of students' success, students' attitudes, students' skill development, teachers, and instructional materials (see Table 1). The preservice teachers felt that DSs may positively affect students' academic success since visual effects have the potential to capture students' attention, increase their concentration, help them relate to real life problems, and enhance their imagination. Moreover, participants observed that students may interpret and solve problems presented through DSs more easily than text-based alternatives. The preservice teachers stated that DSs may improve students' attitudes towards math and problem solving as well as their attendance. The preservice teachers also emphasized how DSs may develop skills related to imagination, interpretation, logical thinking, and long-term capacity. Participants further identified factors related to professional skills such as class management. Since DSs have the potential to make a lesson attractive and entertaining, they help teachers facilitate better learning, follow student performance, and assess students' skills. DSs also offer great versatility in the classroom, incorporating both visuals and audio, and use can range from students creating their own DSs to teachers applying pre-created stories for assessment, introduction, elaboration, or deeper understanding. The preservice teachers also mentioned the affective sides of these materials, as the stories relayed the feelings of the characters, which might affect students. They also described an appropriate fit with the constructivist philosophy when making students prepare DSs or by presenting DSs to enhance student curiosity.

The themes that emerged from focus group interviews regarding future integration were parallel to the open-ended questionnaire in that most of the preservice teachers noted their intentions to use DSs in their future classrooms. The preservice teachers who intended to use DSs emphasized how these materials make lessons enjoyable, capture students' attention, maintain students' concentration, and increase the likelihood of students having positive attitude towards math. The preservice teachers made the following comments:

> *FG_1: I would like to use the digital storytelling technique in problem solving applications in the future. I can make the course more enjoyable using that application. I can use it for drawing attention of the students to the course topic.*
> *FG2: Some students feel that mathematics consists of only numbers and symbols, but in fact, if we use it in the future in our class, we can help our students to feel positive feelings towards mathematics.*
> *FG_3: We would prefer to use DSs in future. We believe these materials help keep students' concentration.*
> *FG_4: In the future, I would use them. I would like to use them for developing positive attitudes towards mathematics in students.*

Moreover, focus group interview results included descriptions of these future integrations, such as presenting created DSs to students before asking them to create their own. The following quotes represent the related focus group interview comments:

> *FG_1: Students should create their stories because creating digital stories has the potential to develop their creativity. But at first teachers should explain what does digital story mean, the process how to create digital stories, and after that students produce their stories.*
> *FG_2: First of all teachers should present created digital stories and next teachers can ask their students to create their own stories.*
> *FG_3: First of all, digital stories should be given to the students at the beginning and then we can ask them to create their digital stories.*
> *FG_4: Digital stories can be produced collectively with students and teachers by asking students their opinions. Teachers should present the created digital stories. Then, the topic and photos can be given to the students before asking them to create their stories*.

The results showed that 3 out of 4 groups stated they would use teacher-produced DSs for different instructional purposes as capturing students' attention and reinforcing, rewarding, and supporting learning. Only one group mentioned firstly student-produced DSs during the interview but then, they emphasized again, teachers firstly should introduce digital storytelling to the students. According to the results, preservice primary school teachers pointed out they would use DSs in line with behaviorist pedagogy consisting of making progress, solving problems, achieving outcomes (Wollard, 2010) in their future integration decision. However, all the groups stated that after they would have used DSs firstly in line with teacher-centered approaches, then they would use them in line with student –centered approaches in that they would make their students create their own stories in line with constructivist pedagogy.

Three preservice primary school teachers intended to use DSs rarely because applying DSs may take extra time in a classroom where teachers already struggle to meet the demands of the national curriculum. They stated students might get bored if DSs were applied too frequently, although they did believe in the potential of DSs to capture students' attention, motivate them, and help them solve problems and improve their problem solving skills. Five preservice teachers explained that they would include DSs depending on such conditions as class size, schedule, student preparedness, and DS quality. They emphasized that teachers must first act in accordance with the schedule of the national curriculum; if they have no problems with the schedule, they could include DSs during problem solving activities. They emphasized that the classroom should not be crowded and students should be in formal operational cognitive development stage to use DS during instruction. One preservice teacher pointed out that he would continue to use DSs in class activities only if his first real application was successful.

Seven preservice primary school teachers did not intend to use DSs during instruction because they felt DSs were killing students' curiosity by providing too much information, while two participants indicated that students may not pay attention to important points presented through DSs. Teachers emphasized the transmission of key information during instruction again and again. Two preservice teachers worried about students losing the ability to concentrate if they missed a piece of information during DS problem presentations, leading to increased misunderstanding of other information. One preservice teacher said that she did not prefer to use DSs during problem solving because students had different preferences and could not learn with such materials. Two preservice teachers simply believed problems should be presented through text. Similar to open-ended questionnaire results, only one negative statement about the use of DSs during problem solving activities was related to concentration loss. A preservice teacher from FG_2 said, "I would not want to use it because students may be distracted. It may remind the students of games."

The preservice primary school teachers were also asked in which topics they would use DSs. Three themes emerged: *topics, use aim,* and *others*. Eleven categories were created under *topics*, two categories under *use aim*, and one category under *others*. From most frequent to the least, the eleven topics were problem solving (n = 63), fractions (n = 38), basic operations (n = 25), geometrical shapes (n = 17), all math topics (n = 13), numbers (n = 12), topics difficult to learn (n = 3), data learning area (n = 2), pattern and tessellation (n = 2), set (n = 1), and measurement (n = 1). The preservice primary school teachers pointed out how they could use DSs to teach numbers by applying both visual and audio components. Moreover, they expressed to use DSs to teach problem solving because it is both difficult and important to learn, also DSs have the potential to capture students' attention. As geometric shapes are difficult to draw, DSs can enhance students' 3D thinking and make knowledge concrete while learning geometry. Some preservice primary school teachers pointed out that DSs might be practical for all math topics, emphasizing DSs' effective use of visuals, real life situations, and interesting stories that hold students' attention.

Three participants stated for what purposes they might use DSs during instruction. Two of them described using DSs for practicing skills after topics and key points were explained in the classroom, while the third indicated using DSs while learning topics during activities. Out of 113 preservice primary school teachers, two emphasized that they would use DSs for concept learning for any math topic.

The focus group interviews supported the open-ended questionnaire in that preservice teachers addressed geometry, fractions, problem solving, topics difficult to teach, and loss of student concentration. In addition, themes emerged related to the classroom timeline (at the beginning, end, and during a course) and the aim of DSs, such as capturing attention and reinforcing, rewarding, or supporting learning. Focus groups made the following related quotes:

> *FG_1: I can use it when I teach numbers, fractions. Sometimes bringing some materials to class can be difficult. So I can show a digital story. I can use it for geometry. I can show the digital story at the beginning of the course and then I*

can ask the students some questions about the story. I can use it at the end of the course for reinforcement.
FG_2: With fractions, numbers, and problem solving, I can use it in some topics which are difficult to make knowledge concrete. I can use it for teaching geometric shapes. I may use it when I feel that students are distracted by some difficult topics for reinforcement and for reward.
FG_3: We can teach at first, and next we can ask students to create digital stories based on the topic that we teach to examine their knowledge levels. We can use them when we realize that students' concentration is dwindling. In every topic and situation we can use that application.
FG_4: If I have the chance, I would like to use that tool for all problems. I would like to use it from first grade. I can use it for solids. I can use it after the topics are taught to reinforce.

To conclude, the results showed that most of the primary school teachers made positive expressions about their experiences of math problem solving experiences by using DSs (see Figure 3). 87 of them wrote advantages of using DSs during their math problem solving while 92 of them explained the advantages of using DSs during students' math problem solving experiences. The most frequently expressed reason of using DSs was that they could contribute to understanding the math problem. The other advantages the primary school teachers expressed related with use of DSs in math problem solving were "making problem concrete", "taking attention", concentration on problem" and "development in skills as mental processing, logical thinking, concentration, listening, creativity, problem solving, mathematics, information connection, visual intelligence, and interpretation". Moreover, 99 of them acknowledged using DSs when they would be a math teacher because they believed that DSs use in math problem solving may enhance students' success and create positive attitudes toward math. They pointed out that DSs help teachers facilitate better learning, and make easy class managements since DSs have the potential to make a lesson attractive and entertaining. Most of the groups stated they would use teacher-produced DSs firstly for different instructional purposes as capturing students' attention and reinforcing, rewarding, and supporting learning, to teach especially problem solving (n = 63), fractions (n = 38), basic operations (n = 25), geometrical shapes (n = 17), all math topics (n = 13), numbers (n = 12) (see Figure 3).

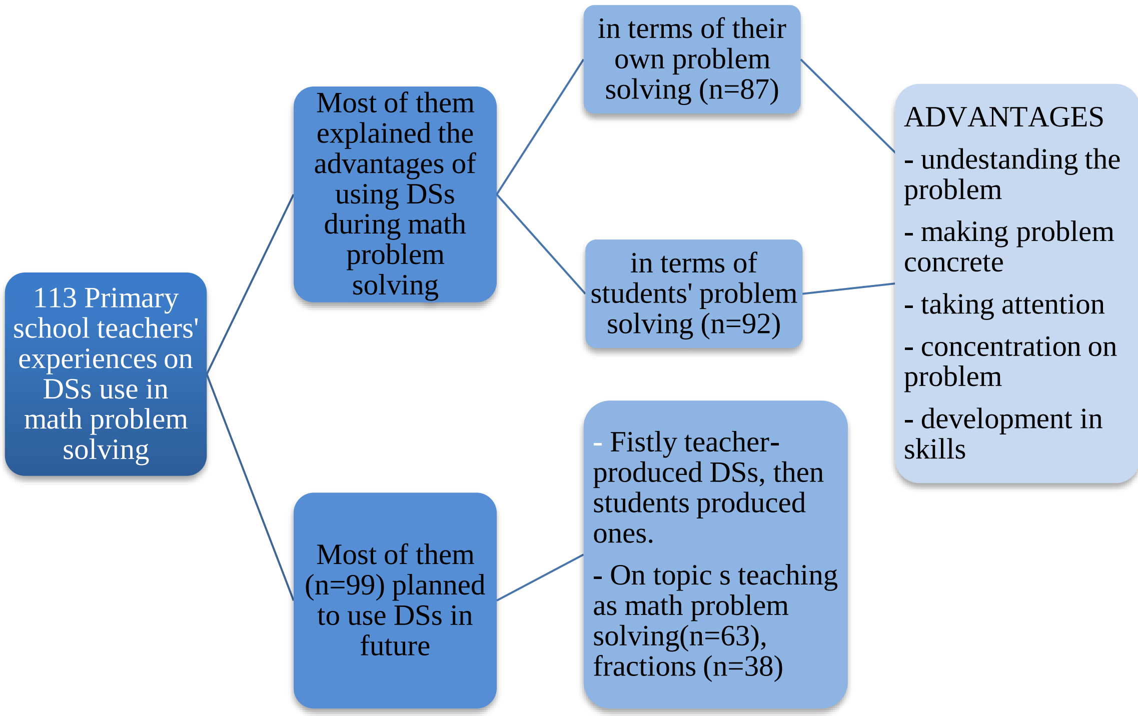

Figure 3. Summary of the study results

Discussion and Conclusion

If future teachers are well instructed in how to integrate technological tools and programs while teaching mathematics, especially in problem solving, they will be more qualified to educate their students. Moreover, as indicated in the literature, technology-supported problem solving applications are very important. The more preservice primary school teachers' experiences are improved, the more they will contribute to future instruction and student learning. Researchers (Bhattacherjee & Premkumar, 2004; Ertmer et al., 2001) have emphasized how the experiences of preservice teachers with technology integration influence their competency, confidence, and future decisions about using technology during instruction. Teachers' experiences with word problem solving also play an important role in their teaching practice. For that reason, the current case study reveals how preservice primary school teachers describe their experiences with digital story-based math problem solving applications and future integration of these technologies.

Most of the preservice primary school teachers showed positive reactions when they speak of their experiences with the digital story-based math problem solving applications. The participants stated that the applications contributed to problem solving processes for both teachers and students, especially in terms of understanding the problem, devising a plan, and carrying it out. According to most of the preservice teachers, DSs enhanced their ability to understand problems and have the potential to do the same for students because the material presents relevant, real life situations. Students can imagine the problem in their minds, making knowledge more concrete and increasing their concentration. They also emphasized how students would pay more attention to the problems because the stories were attractive. The participants believed that since DSs incorporate stories and visuals, students will like math and problem solving activities more and increase their permanent knowledge through entertainment in a positive learning climate. An important number of preservice teachers pointed out that DSs may develop student skills in mental processing, logical thinking, concentration, listening, imagination, problem solving, mathematics, connecting information, visual intelligence, and interpretation. DSs can also contribute in terms of developing positive affective attitudes towards math and problem solving. Therefore, it can be concluded that digital story-based problem solving applications have the potential to develop and enhance students' learning. In addition, according to the literature (Daher, 2009; Kale & Whitehouse, 2012), technology-based problem solving positively affects preservice teachers' problem solving experiences.

A few participants noted negative experiences with the DS-based problem solving applications. One issue was concentration difficulty; another stemmed from the inclusion of excessive details not related to the problem, such as more characters, their feelings, their relationships, and various events.

Results revealed that most preservice primary school mathematics teachers did intend to use digital story-based problem solving applications in their future classrooms. During focus group interviews, they described how they would use DSs at the beginning, end, and throughout their courses for capturing their attention and reinforcing, rewarding, and supporting learning. The preservice primary school teachers planned to themselves present a created DS first, and then asked the students to create their own. According to these results, they would follow behaviorist pedagogy while integrating DSs into their teaching. This finding may stem from the design of the research: the preservice primary school teachers were provided DS-based problem solving applications and then asked about their experiences. They may have described their future DS integrations in line with these experiences.

Most participants state that they would like to use DSs for problem solving applications in their future classrooms. The results of the study indicate that it is necessary to integrate digital story-based problem solving applications into math methods courses in teacher education programs. Most participants planned to use DSs in problem solving situations including fractions, basic operations, geometric shapes, general math topics, numbers, topics difficult to learn, pattern and tessellation, data, set, and measurement. Their positive experiences with digital story-based problem solving applications may have encouraged them to consider these tools in their future teaching. Mumtaz's (2000) literature review about factors that affect teachers' use of information and communications technology (ICT) highlighted the central roles of pedagogy and teachers' beliefs about teaching and learning with ICT. Ertmer (2005) claimed initial experiences (not persuasion) with computer use have a big effect on teachers' technology use in their classrooms. Similarly, Afshari et al. (2009) pointed out the importance of effective training programs that provide future teachers with positive technology integration experiences.

This study is limited to a single exploration of how one group of preservice primary school teachers described their experiences with digital story-based problem solving applications and their future integration plans for these materials. The researchers ultimately cannot know whether the preservice teachers' opinions about future technology integration were directly affected by their exposure in this study to digital story-based problem solving applications. Further study should be conducted applying experimental methodology to investigate the effects of digital story-based problem solving applications on preservice teachers' opinions and plans for use of that technology. Some studies can be conducted in which preservice teachers could create and present problem solving situations using digital storytelling, and the created problems could be analyzed in terms of technological and mathematical aspects.

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