Students Solve Mathematics Word Problems in Animated Cartoons

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ABSTRACT

This study aimed to explore if there are any differences in word problem solving skills of fourth grade students using animated-cartoon story vs. text-only story vs. non-story. For this purpose, word problems-embedded animated cartoon stories were created on computers and the same stories were written in text format on paper. The word problems used in these stories were presented without stories. In an experimental design, a total of 76 fourth graders (38 girls, 38 boys) solved mathematics word problems in a pretest and then in one of three conditions: Animated-cartoon story (n =24), text-only story (n =26), and non-story (n =26). Upon completion of the experiment, students solved mathematics word problems in a posttest. A one-way ANOVA was conducted to reveal the differences between groups' gain scores from pretest to posttest. Results showed a significant improvement and difference for animated-cartoon story group only. This study implies that animated cartoons, when designed as mathematical stories based on anchored instruction framework can support and upgrade students' mathematics problem-solving performances.

Keywords: *animated cartoons, mathematics achievement, animated story, mathematics word problems, anchored instruction*

INTRODUCTION

Ministry of National Education of Turkey (2018) emphasizes the importance of mathematics problem solving and indicates that it has an important function in understanding the relationship between mathematics and everyday life. Specifically, mathematics word problems help students gain knowledge of real-life use of mathematics (De Corte, Greer & Verschaffel, 2000). A word problem solving procedure consist of comprehension of the problem and conducting essential calculations, and successful mathematics word problem solving is generally associated with comprehension of a problem rather than arithmetic calculations (Hickendorff, 2013). In addition, students' failures with mathematics word problems are due to focusing on numbers and keywords only (Aydoğdu & Olkun, 2004) and not being able to comprehend problems well (Yenilmez & Yasa, 2007). For instance, 5th grade students, who were asked the following question by different repeated studies, got the question wrong (e.g. see Bransford & Stein, 1993, Reusser, 1988). "*There are 26 sheep and 10 goats on a ship. How old is the captain?*". The answer to this question was 36, according to 75% of the school children who were asked. Although no information was given about the captain, students added the numbers up in the problem to find out the answer. Additionally, literature indicates that although students could solve basic calculation problems, only a small percent of students were successful with word problems requiring the same calculations (Cummins, Kintsch, Reusser, & Weimer, 1988). This situation is a result of students' problem comprehension failures. Accordingly, students must be supported with the comprehension of a word problem so that they can successfully solve the problems. There are studies in the literature searching for different ways to improve students' understanding of mathematics word problems.

For example, having students reword problems' text (Mellone, Verschaffel, & Van Dooren, 2017), providing verbal instruction on inconsistent words with the required calculations (de Koning, Boonen, & van der Schoot, 2017), providing hints along with visual schemas and spoken instruction on computers (de Kock, 2016), and having students learn planning and working on verbal skills (Mädamürk, Kikas, & Palu, 2016).

A suggested and proven way to improve students' mathematics problem comprehension stands back in 1980s. It is the use of meaningful contexts (Sherwood, Kinzer, Hasselbring, & Bransford, 1987) since meaningful contexts increase students' problem solving performance and interest. The anchored instruction theory, bringing the benefits of situated cognition and situated learning theories into classrooms, uses stories as meaningful contexts with meaningful mathematics problems and necessary data to support students' mathematics problem solving skills. Stories as meaningful contexts are presented via video technology in this framework. On the other hand, animated-cartoons, as a technology medium, are claimed to be yielding successful results in students' mathematics learning and understanding (e.g. see Alexandron, Keinan, Levy, & Hershkovitz, 2018; Oktavianingtyas, Salama, Fatahillah, Monalisa and Setiawan, 2018). This situation brings the idea that in an anchored instruction framework, whether or not presenting stories with different medium such as animated-cartoon environment, would yield successful results on students' mathematics word problem solving.

Studies searching ways to improve students' learning with animated-cartoons are very limited. However, animated-cartoons have advantages over students' learning and yield significantly better achievement results than traditional teaching methods based on related literature. Animated cartoons, especially with their animation features, catch students' attention to the learning environment and help them mentally visualize a learning activity (Dalacosta, Paparrigopoulou-Kamariotaki & Pavlatou, 2011). They support students' reading comprehension, which is highly related to students' mathematics word problem solving. However, the researcher is not aware of a study taking advantage of animated-cartoons in improving students' mathematics word problem solving. In this study, animated-cartoons were not arbitrarily used for improving students' mathematics word problem solving. Instead, the animated-cartoons were created in anchored instruction framework, which support students' mathematics understanding and problem solving. For this, two stories, in which necessary data to solve problems are embedded, were created.

In summary, mathematics word problems are seen as the real-life applications of mathematics problems. However, students mostly have issues with solving these problems. Their mathematics word problem solving failures are mostly related to miscomprehension of the problems or focusing on only numbers and keywords. To support students' problem comprehension, this study used anchored instruction as a framework. Considering suggested benefits, this study utilized animated-cartoons, which are not a commonly used tools to research in students' mathematics word problem solving. Mathematics word problems were presented in animated-cartoons in this study instead of video format in anchored instruction framework to present a story with embedded data, which are necessary to solve problems. The purpose was to investigate whether or not students would improve their mathematics word problem solving performances with the use of animated-cartoons prepared based on anchored instruction framework.

LITERATURE REVIEW

This study examines whether students' mathematics word problem solving achievement improve with animated stories prepared based on anchored instruction framework. Moreover, the purpose was to see whether or not this improvement is significantly higher when students are exposed to the same story in text-based format or when they solve the same problems without a story context. In this part, theoretical background using anchored instruction framework and the use of animated-cartoons in students learning were discussed.

Theoretical Background

Anchored Instruction was used as a theoretical framework to support fourth grade students' mathematics word problem solving in this study. Anchored instruction theory, founded by Cognition and Technology Group at Vanderbilt (CTGV) in 1990, presents meaningful contexts in video-based environments to improve students' mathematics problem solving. This theory has seven design principles: video-based format, narrative with realistic problems, embedded data design, problem complexity, pairs of related adventures, generative format, and links across the curriculum. All problems with hints and feedback were embedded in meaningful contexts (i.e., embedded data design). Meaningful contexts were real stories (i.e., narrative), which were presented in video-format with actors in real life situations (i.e., video-based presentation). Students exposed to anchored instruction are expected to generate new problems, i.e. generative format. Each problem in stories is complex requiring students to solve problems in at least fourteen steps, i.e. problem complexity. Videos present stories containing more than one adventure, which are related, i.e. pairs of related adventures. Mathematics is not solely presented in the videos. Other curriculum areas such as science are linked to mathematics, i.e. links across the curriculum.

This study used two of these principles: The narrative and embedded data design in addition to two different formats explained below. In the narrative format, stories were written as meaningful and motivational contexts for the fourth-grade students' mathematics word problem solving. The problems were embedded in a context in which the mathematics problems were in high accordance with the stories. In the embedded-data design, the stories comprised all the necessary data (e.g. numerical information, feedback and necessary clues) to solve the mathematics word problems. Two different and additional formats were as follows: First, this study used animated cartoons instead of video-based format, which is beneficial for students to comprehend the story better. Second, an individual learning environment was prepared for students to individually solve the problems in the animated-cartoons instead of collaborative learning in anchored instruction.

In this study, the animated-cartoons were based on anchored instruction theory in which stories are given along with story related problems and necessary data to solve these problems. The purpose was to help fourth grade students with their inert knowledge, which is used only if specifically asked for, as claimed by the theory (CTGV, 1990, 1997). In the literature, anchored instruction was found to be motivating for students and improving students' mathematics problem solving ability (Shyu, 2000). Furthermore, students' satisfaction and learning increase more with video medium than text (Choi & Johnson, 2007). Macro-contexts are presented in videos in anchored instruction framework to support problem-based learning and are used for teaching history, science and language arts (Kumar, 2010). Macro-contexts were created as stories presented in video technology for students to explore problems in this framework (Love, 2004). In this respect, it was questioned whether animated-cartoons as medium can be effective on students' mathematics learning in this study. The purpose was particularly to support students improve their mathematics word problem solving skills in animated-cartoons based on anchored instruction theory.

Animated-Cartoons

Cartoons are useful in conveying messages via pictures and symbols from daily life while exaggerating messages and using humor (Dalacosta, Kamariotaki-Paparrigopoulou, Palyvos, & Spyrellis, 2009). Cartoons prove to be effective tools in teaching a variety of topics in different school subjects, such as in chemistry (Byko, 2001) and superior to text-only versions of the same content for recalling information in history (Mallia, 2007). Dalacosta et al. (2009) suggest that animated cartoons could be supportive on students' comprehension and knowledge of difficult science concepts. Generally, students have positive reaction to animated cartoons, which teach principles of macroeconomics, in terms of being interesting, helpful to remember and understand the content (Luccasen, Hammock & Thomas, 2011). Additionally, they were found to be advantageous tools for 13-15 year-old children in understanding stroke (Ohyama et al., 2015).

Another advantage of using animated cartoons in the classroom, even without narration, is that they were found to be more beneficial for long-term memory retention than the equivalent graphics (O'Day, 2007). Animated objects are helpful in catching students' attention, thanks to moving characters, on-screen

text dialogues and narration (Dalacosta et al., 2009). Animated cartoons with their animation feature support teachers to catch students' attention to the learning environment and help students create mental model representation of a learning activity (Dalacosta, Paparrigopoulou-Kamariotaki & Pavlatou, 2011). Specifically, Takacs and Bus (2016) in their eye-tracking study found that animated figures instead of static ones in storybooks attracted students' attention more, when they are related to the specific details necessary to comprehend stories.

The present study examined students' mathematics word problem solving achievement with the use of animated cartoons. Because students' word problem solving is associated with their comprehension issues, it necessitates to take a closer look whether students' reading comprehension can be supported with animated cartoon environments. Related literature shows that students' language related skills and comprehension can be improved with animated cartoons. For instance, Arıkan and Taraf (2010) used animated cartoons to support 4th grade students' vocabulary and grammar learning. They used a well-known cartoon, Simpsons, as an experimental tool for students. The cartoon had similar content as the curriculum. The authors compared the effect of animated cartoon on students' language learning to traditional methods and found a significant difference to the advantage of the animated-cartoon group. Su and Liang (2015) in their three-month long study used animated cartoons vs. traditional textbook learning in supporting students' reading comprehension skills in class. No gender differences were found in students' reading comprehension, however students who watched animated cartoons with subtitles have significantly better improved their reading comprehension skills than those in the text-based CDs group. Pelani (2016) in his study used subtitled animated cartoons for students' reading comprehension and compared whether animated cartoons without subtitles can also support students' reading comprehension. Results showed the animated cartoons with subtitles can greatly support students' reading comprehension. It is because students can synchronously see what they watch and read. Bakla (2018) in his study had 112 learners of English complete either teacher-made animation or PowerPoint activities on common punctuation rules of English. Both groups completed exercises made with software and discussions in a learning platform, Moodle. Results indicated that students in the animation group had significantly better results than the PowerPoint acitivity group and they had highly positive views about the learning activity.

To date, very limited number of studies, which use animated-cartoons as a teaching medium, in learning have been found. Specifically, in mathematics learning, animated cartoons have been subject to research only in recent years and very limited. For instance, in a study by Alexandron et al.(2018) fourth graders were taught fractions with animated-cartoons in an Intelligent Tutoring System. The study measured its effectiveness on students' learning. They found that the majority of the students watched each cartoon (20 cartoons in total) voluntarily. This is a sign of students' interest in this particular learning environment. The results also indicated that watching a cartoon and learning what is taught is positively correlated. Oktavianingtyas, Salama, Fatahillah, Monalisa and Setiawan (2018) created a 3D animated story on proportion subjects in mathematics and utilized problem-based learning in order to support students in comprehending proportion problems and find proportion formulas. The result was positive in terms of students' problem comprehension and finding the formulas.

Although suggested benefits, the researcher is unaware of any previous research conducted specifically on students' mathematics word problem solving achievement in animated cartoon environments. In the present study, instead of using readily available cartoons, a visual programming tool, Scratch programming, was used in order to create an animated cartoon environment to support fourth grade students in solving word problems. Scratch is a visual programming environment with which simulations, cartoons, games, and interactive stories can be created (Ouahbi, Kaddari, Darhmaoui, Elachqar, & Lahmine, 2015). It provides the opportunity to use visuals, voice recording, and sound effects to enrich the visual environment. For this reason, Scratch was used to create an animated mathematics learning environment for fourth graders in this study. This creation process was completed based on anchored instruction framework, which has advantages over students' mathematics learning.

Animated-cartoons instead of video-based format in anchored instruction was used in this study. These animated-cartoons were based on two design principles of anchored instruction framework: embedded data design and narrative format. Animated stories were claimed to be supporting students' comprehension (Pelani, 2016; Takacs & Bus, 2016) and motivation (Dalacosta et al., 2009; Su & Liang, 2015). These benefits are also claimed in the theory for the video-based format as the hypothesized benefits (CTGV, 1997). Additionally, all the necessary data including feedback, hints and numerical information was embedded in a story for students to find necessary data to solve problems. Story was used as narrative format to show students how and where mathematics is used in daily life. This is the hypothesized benefits of narrative format in anchored instruction framework that narratives help students realize how mathematics and real life are connected. For these reasons, an anchored instruction framework was utilized in preparing animated-cartoons.

In summary, in the present study, the effect of animated cartoon environment on students' mathematics word problem solving achievement was investigated with fourth grade students. The animated cartoons were created based on anchored instruction framework and presented to the students in an individual learning environment on computers. Thus, the research question in this study was that "To what extent are animated cartoons effective on fourth graders' word problem solving achievement?".

RESEARCH METHOD

Participants

In total, 76 fourth grade students participated in the present study. The students were from a public elementary school in Kars, Turkey. First of all, all the testing materials and scope of the study were reported to Kars Provincial Directorate of National Education to get consent for conducting the study. Upon receiving the consent, information about schools in the region was gathered from the Provincial Directorate. This information included the public elementary schools in the region, which are similar based on students' level, socio-economic status, and achievement. Among the schools suggested, one school was randomly selected. In this school, 76 fourth grade students (38 girls, 38 boys) participated in the experiment.

Design and Procedure

In a quantitative research method, a randomized-to-groups pretest-posttest experimental design was utilized. The effect of animated cartoons on fourth graders' mathematics word problem solving achievement was tested in this design. This design is called true experiment, in which participants are randomly assigned to experimental groups either before or after pre-test (McMillan, 2012). In the present study, the subjects were randomly assigned to the experimental and control groups and then pre-test scores between the groups were compared for any differences. The groups' pretest scores were not significantly different (see Results). In the study, the subjects were pre-tested, given one of the three treatments, and then post-tested. The study was completed in four weeks during routine school hours. In the first week, to determine students' pre-levels in mathematics word problem solving, a mathematics word problem solving pretest were administered to all subjects (N=76, 38 girls, 38 boys). Then, all subjects randomly were selected with a *simple random sampling* method and assigned to experiment and control groups, in which they completed the treatments individually: Animated-cartoon story (n=24), text-only story (n=26), and no-story (n=26). For the animated-cartoon story treatment, two animated cartoon mathematics stories, created on Scratch programming, were presented on computer. For the text-only treatment, the same stories were presented on paper. For the no-story treatment, the word problems from the stories were presented on paper without a story. They solved exactly the same problems in different conditions. This process was completed in the second and third weeks. In the fourth week, they solved the problems in the word problem-solving posttests individually. A one-way ANOVA, with three levels of treatments (animated-cartoon story, text-only story and no-story) was conducted to analyze students' problem-solving achievement, which was measured with their gain scores from pretest to posttest.

Instrumentation

Mathematics Word Problems Pre and Posttests

Two different mathematics word problem tests were prepared as pre and posttests to measure students' word problem solving ability. The mathematics problems were based on the mathematics academic standards prepared by the Ministry of National Education in 2018. Specifically, the target was the combination of the M4.1.10, M4.1.14, M4.1.20, and M4.1.26 targets: "Solves and sets up word problems that require addition; subtraction; multiplication; division". A sample question was as following:

"*In a bag, there are 25 pencil cases, containing 12 pencils each. If so, how many pencils are there in 10 bags?*"

Initially, both tests included twelve open-ended word problems. The tests were named Test 1 and Test 2. Each problem in Test 1 was parallel to the corresponding problem in Test 2. For example, the first question in Test 1 required the same solution as the first question in Test 2. However, they had *different contexts*. To determine whether the two tests were measuring the same ability, a parallel-forms reliability test was conducted. For this, 60 fourth-grade students solved the problems in the tests. They were divided into two groups (i.e., two seperate groups with 30 students) randomly. While one group completed Test 1 first and Test 2 second, the other group completed Test 2 first and Test 1 second. A parallel-forms reliability test was used to see whether the two tests were measuring the same problem-solving ability. The purpose was also to ensure the internal validity. After removing two problems, which were significantly different from each other, the pre and the posttest with ten problems were compared. No significant difference between students' scores was found on the tests and both tests were equivalent (t (59) = .168, p =. 867).

The pre and posttests, administered individually, took approximately 20 – 25 minutes to complete. Students completed these tests, each including ten open-ended word problems, before and after the experiments. The grading procedure for the tests was explained in the results section.

Story Contexts

Two story contexts were written for the experiment. The purpose of these stories was to provide meaningful contexts for fourth-grade students' word problem understanding. Both stories were used in both animated-cartoon and text format in this study.

The first story is about a teacher and her students (see Figure 1). The teacher wants to take her students who are successful in the exam to a movie theater. She asks them to calculate the marks one could get on the exam based on the number of correct answers. On the day of theater activity, they need to calculate taxi fare to the theater. In the movie theater, they see a cashier who sells the cinema tickets. The cashier offers them *buy 4 get 1 free ticket* promotion and asks them how much they should pay for all the tickets. In addition to these problems, they calculate a time problem to the movie's start, popcorn fee calculation problem etc. in their movie theater activities. Finally, they calculate bus tickets fee on their way home. One sample question is:

"*We spent 80 Turkish liras for the taxi, 156 Turkish liras for the tickets and 9 Turkish liras for the chocolates. In total, how much money did we spend?*"

All the mathematics word problems, as well as feedback and hints, were embedded in the first story context. Students were expected to solve all these mathematics word problems within the story context.

The second story was about animals instead of humans to present a different type of adventure for students (see Figure 2). In this story, mathematics word problems represented real life problems in the context. This story takes place in a forest between two penguins escaping from the South Pole to discover a new place. After deciding to an adventure, they arrive at a forest, where they take a walk, look around the trees, animals, and fruits in wonder. During their walk, they encounter mathematics word problems in the

forest. For example, they get hungry and then see apples on an apple tree. They wonder if they could get any apple from the tree. All of a sudden, the tree starts to talk and say that he could give them apples only if the penguins answer to an apple related word problem correctly:

"I have 100 green and 50 red apples on my branches. However, 20 of them are rotten apples. So tell me, how many fresh apples do I have?"

Additionally, the penguins come across a gazelle, a lion etc., who ask mathematical problems in the forest. During the adventure, they count the number of their steps or the number of cherries, for example. All the mathematics word problems with feedback and hints were again embedded in the story context.

In the case of animation, the problems are given along with animated objects such as students, taxi, cashier etc. in the first story, and penguins, lions etc. in the second story. Background images related to the story scenes were also given to support students' problem understanding. For the text-only story, the story was given without these supports.

Animated Cartoons

Two animated cartoons were prepared based on the story contexts described above (see Figures). These animated cartoons were created on Scratch programming and required Scratch program set up on computers to work, without the need of an Internet connection. The participants were provided headphones before starting to the animated-cartoon treatment. Once the green flag on the top right side of Scratch program is clicked on, the animations start. Voice-over narration, conversations between the characters, static pictures representing the problem context, e.g. classroom, cinema, bus, forest, trees, etc. and animated characters are used in the animations. The stories were vocalized and recorded on Scratch programming for students to listen to.

At the very beginning of the animated-cartoons, an introduction to the story was narrated along with related pictures representing the story plot scene and the characters. The idea at this point was to help students grasp the main idea of the story. The programs are a sequence of different scenes with visual images representing the problems. Once a problem is presented as text and narration, a dialog box is provided at the bottom of the animated-cartoon screen into which the participants type their answers. This box appears after each problem is completely narrated. Students had to solve the problems on a scratch paper first, and then type their answers in these boxes. They were allowed two attempts for each answer. Automated solution feedback was provided for correct or wrong answers. The feedback was provided as conversation between the characters as the part of the story. Here is a sample feedback:

"Kids, if we purchase 12 tickets, we divide 12 by 4 which is equal to 3. That means that we will get 3 tickets for free. The number of tickets we need to buy is 12."

After the feedback was narrated, the story continued. The scene after this point changed with different images and related narrations. When the characters left a scene, they were animated as if they were walking off the scene. Then, another scene of the story would appear with a relevant background picture and animated objects.

Students completed the stories one after the other, solved the problems within the story contexts and finished the experiment. There was no time limit for students to complete the animated cartoons. Depending on students' word problem solving speeds within the story context, this process was completed approximately from 20 to 30 minutes.
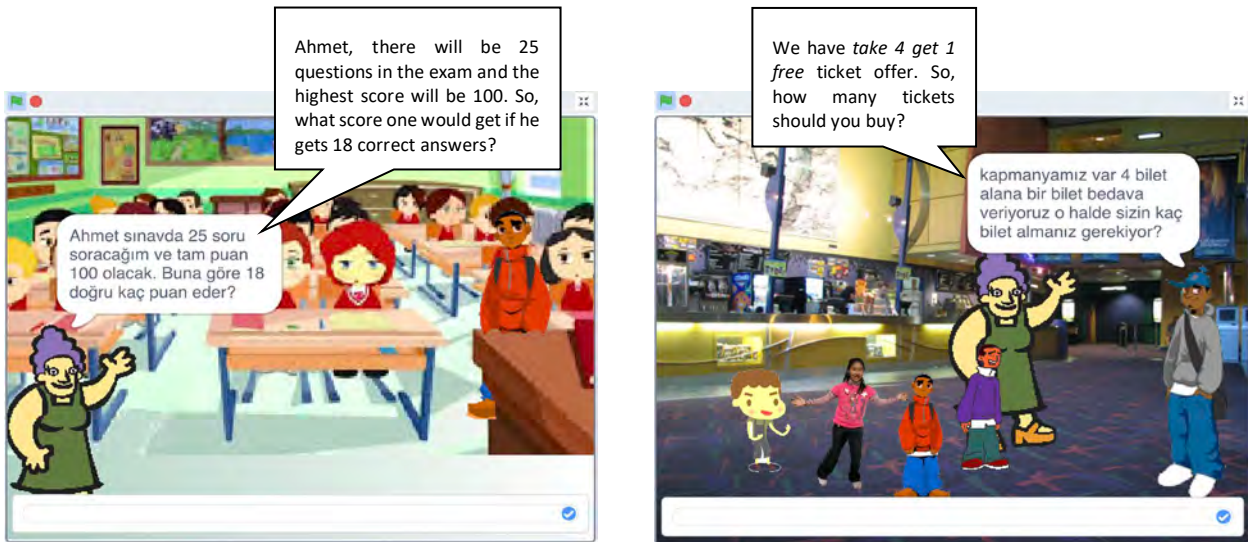
Figure 1. Animated cartoon 1-Teacher is taking her students, who are successful in the exam, to a movie theater
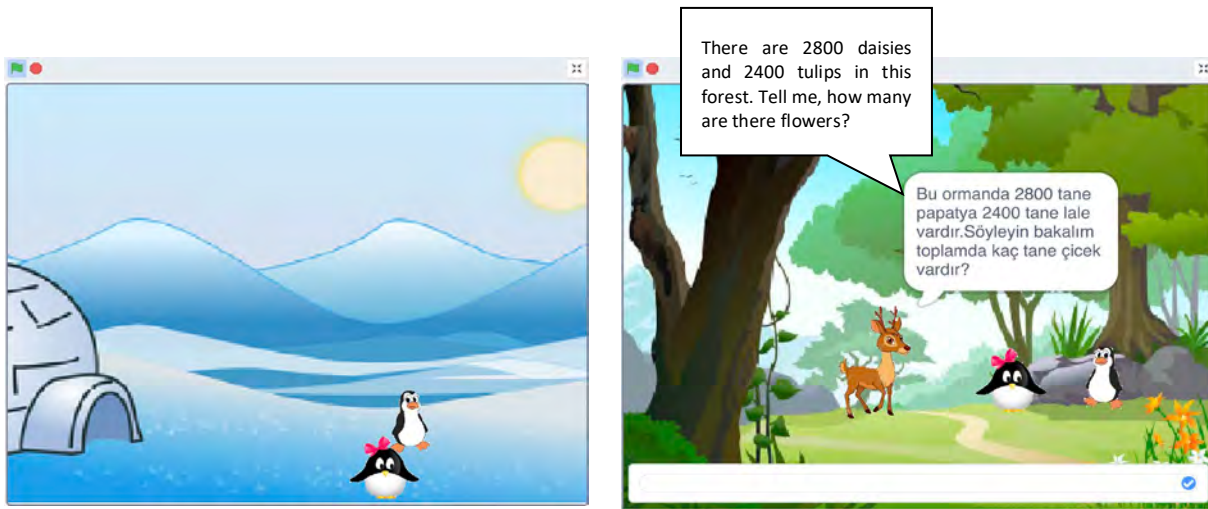

Figure 2. Animated cartoon 2-Two penguins escaping from the South Pole to discover a new place

Text-Based Stories

The text-based stories were the same story contexts as those in the animated-stories. They included the same mathematics word problems. However, students in the text-only story group solved the problems in traditional print form, 5-6 page-long stories. These stories were presented to the students in traditional paper format, which were typed in a word processor and stapled. They were all-text with no pictures. Students were asked to solve the problems in the story pages on the spaces provided underneath each problem. They read the stories one after the other, solved the problems and finished the experiment.

FINDINGS

Scoring and Analyzing

Students' number of correct answers on their pre and post-tests determined their mathematics word problem solving scores. An expert in mathematics education was asked for his view about the grading the pretest and posttest. Based on his view, a grading scale was prepared. This scale was prepared for each single problem in the tests and determined necessary conceptual and procedural procedures in the problems. Students were expected to show the accurate procedure to solve the problems and perform these procedures correctly to get points on their answer sheets. The number of corrects on pre and posttests was

determined by the sum of students' conceptual (i.e., showing addition, subtraction, multiplication or division) and procedural procedures (i.e., conducting calculations correctly) in their problem-solving processes. Each correct conceptual and procedural procedure received 1 point for each question. The maximum points one could obtain from each test was 40, which was the sum of conceptual and procedural scores on the questions. The gain scores were determined by the subtraction of posttest scores from the pretest scores. An example for grading students' problem solving is as follows:

"A movie was screened in a movie theater. 6857 audiences in the first week of its release and 7658 audiences in the second week of its release watched the movie in the theater. If total number of audiences, who watched the movie in three weeks, is 19172, how many audiences watched the movie in the third week?"

This problem requires an addition and a subtraction concepts and their correctly conducted procedures to be correctly solved. The solution for this problem: For two weeks, 6857 + 7658 = 14515 audiences watch the movie. In the third week, 19172 − 14515 = 4657 audiences watched the movie. Conceptual points one could get from this solution is 2 because it requires 2 conceptual procedure (i.e., addition and subtraction). Procedural points one could get from this solution is 2, which requires correctly conducting these addition and subtraction. In case students solve this problem differently by using only two subtractions, it still gets the same score, which is 4. As a result, students can get 4 points from the solution of this problem. Both pretest and posttest were graded with this procedure and students' total scores were analyzed to reveal the differences.

Group comparisons were analyzed by using a one-way ANOVA test. Before conducting an ANOVA test, assumptions for the ANOVA, independence of cases, normality and homogeneity of variances were checked. All the assumptions were met; thus, a one-way ANOVA was appropriate to compare the groups' achievements.

Fourth Grade Students' Word Problem Achievement

After randomly assigning students into groups, the pretest scores of each group was compared to see if there is a significant difference. One-way ANOVA was used to compare group's pretest scores. Results showed no significant difference between students' pretest scores ($F (2, 74) = .229$, $p = .799$) in the animated-cartoon story treatment ($M = 16.92$, $SD = 8.92$) in the text-only story treatment ($M = 16.35$, $SD = 9.19$) and in the isolated problems treatment ($M = 18.00$, $SD = 8.90$), (see Table 1).

Table 1. One-Way ANOVA Analysis Results on Pretest Scores

Source	df	SS	MS	F	p
Between Groups	2	36.637	18.319	.226	.799
Within Groups	73	5925.718	81.174		
Total	75	5962.355			

($N = 76$)

A one-way ANOVA was run on students' problem solving gain scores to reveal differences, if any, between groups. The results indicated a statistically significant difference between the groups' gain scores ($F (2, 74) = 7.410$, $p = .001$). (see Table 2)

Table 2. One-Way ANOVA Analysis Results on Groups' Pretest to Posttest Gain Scores

Source	df	SS	MS	F	p
Between Groups	2	358.952	179.476	7.410*	.001
Within Groups	73	1768.035	24.220		
Total	75	2126.987			

*$p<.05$, ($N = 76$)

A post-hoc comparison using the Tukey test was conducted to reveal where this difference lies in groups' problem-solving achievements, measured by the gain scores of the groups. The Tukey comparisons (see Table 3) revealed that the animated story group has significantly higher problem-solving scores than the text-only story group (mean difference = 3.580; p = .032) and the isolated problems group (mean difference = 5.272; p = .001). However, no significant difference found between the text-only story and the isolated-problems groups (mean difference = 1.692; p = .434).

Table 3. Contrast Results and Standard Errors for the Groups' Gain Scores

Treatment	Comparison	Mean Difference	SE	p
Animated Story	Text-only Story	3.580*	1.393	.032
	Isolated Problems	5.272*	1.393	.001
Text-only Story	Animated Story	-3.580*	1.393	.032
	Isolated Problems	1.692	1.365	.434
Isolated Problems	Animated Story	5.272*	1.393	.001
	Text-only Story	-1.692	1.365	.434

*p <.05, Results are based on the post-hoc comparison: Tukey test

In fact, there was only a statistically significant increase for the animation group from pretest (M = 16.92, SD = 8.92) to posttest (M = 19.46, SD = 9.82), t (23) = 2.634, p= .015. However, there was a decrease for the text-only story group from pretest (M = 16.35, SD = 9.19) to posttest (M = 15.31, SD = 8.71), t (25) = -1.511, p= .143. There was a statistically significant decrease for the isolated-problems group from pretest (M = 18.00, SD = 8.90) to posttest (M = 15.27, SD = 10.27), t (25) = -2.262, p= .033, (see Table 4).

Table 4. Group Descriptive and the t-test Results Comparing Pretest and Posttest of the Groups

Group	Pretest		Posttest		
	M	SD	M	SD	t-test
Animated Story	16.92	8.92	19.46	9.82	2.634*
Text-only Story	16.35	9.19	15.31	8.71	-1.511
Isolated Problems	18.00	8.90	15.27	10.27	-2.262*

*p<.05.

DISCUSSION

This study explored the effect of animated-cartoon story on fourth-grade students' mathematics word problem solving achievement. Fourth-grade students were exposed to three types of instructions, in which they solved the same mathematics word problems: animated-cartoon story, paper-based story and no-story. They completed mathematics pre and posttests before and after the experiments.

The results indicated that the fourth-grade students in the animated-cartoon story group have a significant improvement in their word problem-solving achievement from pretest to posttest. Moreover, this improvement was significantly higher than those, who solved the same problems in text-only stories and those who solved the same problems without a story. This result might be attributed to providing meaningful contexts for students' mathematics word problem solving since meaningful contexts have a positive affect on students' problem-solving performance (Sherwood, Kinzer, Hasselbring, & Bransford, 1987). Both animated-cartoon story and text-only story included the same context for mathematics problems. However, only animated-cartoon story significantly improved students' mathematics problem solving performances. Text-only story didn't help students with their problem solving. In fact, their problem-solving performances decreased. Previous studies indicate that animated-cartoon environments are more helpful for students' learning than traditional learning environments (Arıkan & Taraf, 2010; Su & Liang, 2015). In line with these studies, we can conclude that animated-cartoon environment can be more beneficial in presenting meaningful contexts for students' mathematics word problem solving than traditional methods.

Moreover, as mentioned earlier, this study used animated-cartoon format instead of video format in anchored instruction framework. Some of hypothesized benefits of video-based format in anchored instruction framework are "more motivating, supports complex comprehension and especially helpful for poor readers" (CTGV, 1997, p. 46). Relevant literature shows that animated stories are motivating (Dalacosta et al., 2009; Su & Liang, 2015) and support comprehension (Pelani, 2016; Takacs & Bus, 2016). Based on these assertions, this study used animated-story instead of video format to assist students' problem solving. Since the fourth-grade students' mathematics word problem solving significantly has increased, the result of this study indicates not only video format but also animated cartoon format can be used in anchored instruction framework. Moreover, one of suggested benefits of narrative format in anchored instruction framework is that it "primes students to notice the relevance of mathematics and reasoning everyday events" (p. 46). Ministry of National Education of Turkey (2018) emphasizes the importance of understanding the relationship between mathematics and everyday life. For these reasons, the mathematics word problems were embedded in a story to take advantage of narrative format in anchored instruction framework. As in anchored instruction framework, narrative format was supportive for students' problem solving in an individual animated-cartoon learning environment. However, it is beneficial only when presented in an animated-cartoon environment rather than traditional method. As a result, in an anchored instruction framework animated environment can be taken as an aid for students´ word problem solving.

An individual learning environment was presented to students to individually solve the problems in the animated cartoons instead of collaborative learning in anchored instruction framework. A recent study by Zambrano, Kirschner, Sweller and Kirschner (2019) shows that collaborative learning can be unnecessary for advanced students and may not all the time yield better learning than individual learning. In all three conditions, students solved the same problems individually in the present study. Among the groups, only the participants of the animated cartoon group improved their problem-solving skills. Moreover, this improvement was significant and better than the one of the other two groups. As a result, we can conclude that in an anchored instruction framework, students can also improve their problem solving when they solve problems individually. Collaborative learning doesn't have to be provided in anchored instruction framework and it may not be always beneficial. This means that, when word problems are presented in an animated cartoon environment in the framework, students can improve their problem-solving skills in individual learning.

In an anchored instruction framework based on embedded data design principle, the stories consisted of the necessary data, i.e. numerical information, feedback and necessary clues, to solve the mathematics word problems. Students were provided feedback based on their own individual answers. In case they solved a problem wrong twice, they received a narrated explanation about the correct solution. This was only the case in the animated story format because traditionally presented problems, either with or without story, do not have such possibility. We can therefore conclude that students took advantage of the narrated feedback presented in animated-cartoon story and accordingly an improvement was observed in their problem solving. This is consistent with earlier studies that narrated feedback increase students' academic performance and concept understanding (Chiang & Vazquez, 2017; Hautala, Baker, Keurulainen, Ronimus, Richardson & Cole, 2018). Moreover, presenting feedback is one of the benefits of computer assisted instruction (CAI), which provides students with the opportunity to learn based on their own needs. Consistent with the studies in the literature (e.g. see Yesilyurt, 2010; Basciftci & Sunay, 2011), the results of this study imply that the animated story given on computer in CAI format, as an individual learning environment, was more effective than the traditional learning. As a result, we can conclude that presenting feedback in a computer-assisted instruction (CAI) is beneficial for students' mathematics word problem solving.

In the literature, animated cartoons were found to be beneficial for students learning in science (Dalacosta et al., 2009), macroeconomics (Luccasen, Hammock & Thomas 2011), biology (O'Day, 2007), and English (Su & Liang, 2015). Animated cartoons served as a mathematical learning platform for fourth graders in this study. In addition to science, macroeconomics and English learning, the result of this study showed that animated-cartoon-based learning environment is also supportive for students' mathematics learning.

Moreover, this result is consistent with Alexandron et al. (2018) study which shows animated cartoons can be helpful for students' mathematics learning. The present study used 2D animated cartoon to assist students' mathematics word problem solving which was not tested before. Results indicated that not only 3D animations (e.g. see Oktavianingtyas, Salama, Fatahillah, Monalisa and Setiawan, 2018) but also 2D animations can also be supportive on students' mathematics learning.

The problem situations in the animated stories were presented in text and with relevant pictures in this study to support students' problem comprehension. Animated-cartoon group have significantly increased their mathematics word problem solving achievements. Considering students' mathematics word problem solving achievements are highly related to their problem comprehension (Aydoğdu & Olkun, 2004; Yenilmez & Yasa, 2007), the results in the present study can be interpreted as the animated cartoons supported students' problem comprehension. This result is consisted with previous studies that animated cartoons with synchronous subtitle text, support students' reading comprehension (Pelani, 2016). It can accordingly be claimed that problem texts presented synchronously with representative animated and static pictures in animated-cartoon environments can be comprehended well by students.

Moreover, as mentioned in the literature, animated objects catch students' attention more than static pictures (Dalacosta et al. (2009). They may look interesting and attractive to students (Su & Liang, 2015) and support story comprehension (Takacs & Bus, 2016). Once students' attention is caught by animated cartoons, instructional messages can be meaningfully delivered to students (Dalacosta et al. 2011). According to Alexandron et al. (2018), animated cartoons are helpful for students' mathematics learning because they support students' interests as well. Informal conversations were conducted with students upon the completing the tasks in the animated-cartoons. Their reactions were positive and they even asked if there were more animations that they could complete. It can thus be concluded that the animated figures attracted students' interest more, as they showed continuous interest in the digital materials beyond the experiment and paid significantly more attention to the learning environments. As a result, the result of this study is in line with these studies and shows that students in animated cartoon group statistically improved their word problem solving scores. That means that they paid attention due to images of animated objects in the animated-cartoons.

CONCLUSION

This study implies that animated-cartoons, designed as mathematical stories in anchored instruction framework, can support and upgrade students' mathematics word problem-solving performances. Additionally, the results imply that such stories are not only beneficial when given in video format as in anchored instruction framework. Animated story format can also be benefited in this framework. Moreover, students can improve their word problem solving performances when they solve problems in animated cartoon format individually as opposed to collaboratively in an anchored instruction framework. As like other content areas, animated learning environments could therefore be used advantageously for constructive mathematics learning. Such results could be achieved as the learning material attracts students' attention more, is more interesting and fun, and supports problem comprehension as suggested and confirmed in the literature. Therefore, animated-cartoons can be designed based on learning theories, such as anchored instruction, and screened in classrooms and even on TVs for children. As children pay attention to cartoons, they can both enjoy mathematics and learn it in fun way.

Amongst the studies in the literature, this study implies that animated-cartoons can be effective tools for also students' mathematics word problem solving. However, mathematics learning in animated-cartoons environment still needs more work. Accordingly, future studies can be tested in different subjects of mathematics and the effect of animated-cartoons on different subjects can be revealed. Additionally, students improved their mathematics word problem solving achievement in animated-cartoons. This result was explained by students' comprehension since word problem solving and problem comprehension is positively correlated. It is necessary to mentioned that students are seemingly interested in the animated condition. However, no formal interviews were conducted to confirm that. For this reason, future studies can be conducted to reveal students' reactions to the stories to explain whether or not other factors such as

interest is also effective on the results. Moreover, students' motivation could be examined to reveal whether stories in animated-cartoon format instead of text-format are more beneficial due to an increased motivation level to solve problems in animated-cartoon format.

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