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ORIGINAL ARTICLE

Using augmented reality technology in storytelling activities: examining elementary students' narrative skill and creativity

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Abstract The aim of the study was to examine the effects of augmented reality technology on stories in terms of narrative skill, story length and creativity and also to examine correlations between these variables. Posttest-only design with a nonequivalent group model was used. In this study, the sample consisted of 100 fifth-grade elementary students, comprising 46 boys and 54 girls. Purposive and convenience sampling methods were applied. For purposive sampling, the group's ages, education levels, and experiences in storytelling activities were gathered, and for convenience sampling, easy access to schools was considered. As data collection tools, a suitable narrative scale was used which was found in the literature and creative story form was developed by the researcher. According to the findings, mean scores for all variables for the experimental group were higher than those for the control group. Also, a statistically significant mean difference was found between the experimental and control groups with regard to narrative skill, length of stories, and creativity in stories. In fact, a positive correlation was found between all variables. It is important to recognize when a technology is found to contribute positively to narrative skill and creativity in telling stories, and to ensure this technology is used. Determining correlation between these variables may provide a contribution to studies about evaluating the effect of the new technologies.

Keywords Interactive learning environments · Augmented reality · Media in education · Virtual reality · Storytelling

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1 Introduction

Storytelling has been used for both entertainment and educational purposes for generations, proving to be an effective educational method (Wang et al. 2013; Zhou et al. 2004a). Recently, computer-supported systems and applications have been introduced with the goals of improving students' engagement and entertainment during storytelling activities (Fridin 2014). Technology-supported storytelling activities have been used as an effective method of achieving these goals (Cassell and Ryokai 2001; Fridin 2014). Kara et al. (2013) stated that new technologies were needed to support children's storytelling activities actively and appropriately. Augmented reality (AR) is one such new technology that has attracted attention and can be used in storytelling (Chiang and Chen 2012). Interactive storytelling systems provide a wide range of interaction options. Children can listen to stories or tell and interact with a story of their own. However, a connection to the physical environment is lacking in these programs. Negotiating the physical world is a critical part of a child's early cognitive development (Vygotsky 1986). Because AR can provide physical and virtual world environments in real time, this technology may play an important role in filling this gap. For this reason, researchers have focused on integrating AR technology into schools, especially elementary schools (Schrier 2006; Sumadio and Rambli 2010). Besides, AR is a new, easy-to-use, and interesting technology and has used in entertainment field. There are number of AR games and mobile applications and still continue to develop them. Since AR is especially an attractive technology, one of the important properties of it, it is thought that AR encourages educators to make use of them. In addition, AR makes storytelling activities attractive for students through providing 3D (three-dimensional) learning content and

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demonstrating virtual 3D objects. Therefore, this study focuses on integrating AR technology with storytelling activities.

Cassell and Ryokai (2001) have observed that technology-supported storytelling activities are more creative, imaginative, and adaptable. Of all these traits, creativity is especially valued in the twenty-first century, yet promoting it is a major challenge in education (Cellary 2002). In this context, we examined students' creativity in stories. As the availability of suitable scales to specifically measure creativity in stories is very limited, a new way of determining creativity is needed. The aim of the study was to examine the effects of AR technology on stories in terms of students' narrative skill, story length, and their creativity, as well as to examine correlations between these variables. Two questions drove the research:

1. Are there any differences between the experimental and control groups in terms of the length of students' stories, narrative skill, and the degree of creativity shown in the stories?
2. Are there any correlations between the length of students' stories, narrative skill, and the level of creativity shown in the stories?

1.1 Augmented reality

AR is defined as a technology that allows virtual information to display real-world environments in real time (Azuma 1997). It provides deep interaction, natural experiences, and a flexible environment. AR transforms empty spaces into rich learning experiences (Alcañiz et al. 2010). It is especially popular for teaching dangerous, complex, or abstract concepts or for presenting objects that are otherwise not possible to see with the eye (Walczak et al. 2006). It also enhances interpreting, problem solving and creative thinking skills and motivation (Azuma 2004; Ivanova and Ivanov 2011; O'Brien and Toms 2005; Schrier 2006; Squire et al. 2008). Although AR provides an important contribution to education, it also presents significant challenges. First, developing and implementing educational AR content is a major problem, as many teachers and students are biased against applications that require technical knowledge (Yuen et al. 2011). The second problem is external factors such as light effects, output, and image quality. Furthermore, students face difficulties in the learning process because they may encounter large amounts of information that cause an increase in their cognitive loads. Students may need to use more than one device, requiring skills in cooperation, problem solving, and manipulating technology (Wu et al. 2013). Despite these technical and pedagogical problems, AR has positively affected the learning process (Billinghurst et al. 2001; Dünser and Hornecker 2007b; Farias and Dantas 2011; Kaufmann and Papp 2006; Kerawalla et al. 2006; Oh and Woo 2008).

In the literature, there have been many studies of AR applications in different fields of education, for example: physics education, biology education, literacy, medical/anatomy education, science education, mathematics/geometry education, engineering education, chemistry education, astronomy education. In physics education, researchers compared traditional methods and AR technology in terms of laboratory skills and attitudes toward laboratories. According to their results, AR technology improved the students' laboratory skills and contributed them to build positive attitudes toward physics laboratories (Akçayir et al. 2016). Lin et al. (2012) developed an elastic impact application with AR technology. Their results showed that learners significantly gained their knowledge with AR Physics system. Yoon et al. (2012) determined the practicality of AR applications in education and developed a conceptual understanding of scientific phenomena. Their results indicated that AR provided positive contribution on engaging with the scientific content and their understanding. In biology education, researchers developed AR contents (*A virtual butterfly garden*) and examined students' academic achievement. According to their results, using AR system could improve students learning effectively (Tarng et al. 2015). Balog and Pribeanu (2010) determined role of perceived enjoyment in the students' acceptance of an AR teaching platform. Their results indicated that perceived usefulness and perceived enjoyment were important factors for behavioral intention to use AR teaching platform. Kye and Kim (2008) examined the influence of factors related to AR technologies on learning. The results showed that sensory immersion, manipulation, presence, and flow had meaningful influence on learning effects of AR application. In chemistry education, researchers used AR to display crystal structures in 3D (Núñez et al. 2008) and to examine molecular structures (Singhal et al. 2012), compared AR models and other models, and determined the interactions between them (Chen 2006). Their results indicated that using AR in education helped students to enjoy it and learn more chemistry (Núñez et al. 2008; Singhal et al. 2012) and students tended to treat AR as real object in interactions with AR (Chen 2006). In mathematics/geometry education, researchers displayed complex 3D mathematical structures in the StudierStube project (Schmalstieg et al. 2002), developed a mobile AR application for geometry education (Kaufmann 2004), and studied collaborative learning for geometry education (Kaufmann and Schmalstieg 2003). Their results indicated that using AR in geometry education was easy to learn, encouraged learners to explore geometry and improved spatial skills. In medical/anatomy education, researchers

integrated AR in simulation and indicated that the simulation provided authentic interactions, and potentially assisted learning (Carlson and Gagnon 2016). Chien et al. (2010) used AR technology to teach bone structures to students, and they could learn the complex anatomy structure better and faster than only with traditional methods. In literacy education, researchers developed an AR book that includes texts, pictures, 3D objects and they took positive feedbacks from users (Billinghurst et al. 2001). Others examined the effect of AR on students' reading skills (Dünser 2008). According to the results, AR books provided low ability readers to interactively engage with the content. In astronomy education, researchers examined the relationship between the Earth and the Sun by using AR (Shelton and Hedley 2002). They indicated that there was a significant improvement in student understanding and a decrease in their misunderstanding.

As is seen in the literature, there are many studies on AR in education. In this study, AR was used as an educational medium to enhance students' narrative skill and creativity. In particular, storytelling activities designed with 3D content present us with more objects, characters, and allow different choices and ways to interact (Kim et al. 2013). When students create stories in their minds and use AR technology to tell their story, they can "see" their imaginations by means of AR technology, providing 3D views of characters and objects. When the students make characters move in the screen, 3D images move simultaneously and this makes a significant contribution to the creation of a story (Kara et al. 2013). AR, as it contains 3D properties, makes the storytelling activities more interesting and can capture the students' attention over an extended period. Furthermore, students are thrilled with 3D objects, making the events more meaningful and converting the whole learning process into a more enjoyable one. In addition, it is considered that students' level of engagement rises as they interact with the characters through moving them in the screen. Accordingly, it is observed that there has been an increase in applications of story creations, with AR covering 3D multi-environment elements nowadays (Chiang and Chen 2012; Zhou et al. 2004b). AR makes it possible to create more interactive, more interesting, more meaningful and more creative stories (Zhou et al. 2004b). In particular, it is thought that AR may provide an important contribution to the storytelling process through AR's ability to convert objects from two-dimensional (2D) to 3D and creating a sense of magic (Billinghurst et al. 2001; Bujak et al. 2013). For this reason, this technology can enhance students' narrative skill, which can be regarded as the ability to set and tell a story effectively. Alsumait and Al-Musawi (2013) said that storytelling is more effective because AR allows 3D content. Therefore, the purpose of this study was to investigate the effects of AR on students' creativity with regard to storytelling and narrative skills.

1.2 Storytelling

Storytelling is a form of communication in which people share understandings and experiences (Cassell and Ryokai 2001; Kara et al. 2013) and a traditional way to transfer knowledge, values, and beliefs (Coulter et al. 2007). It has played a part in human culture throughout history and is well proven as an effective method in education (Wang et al. 2013). Storytelling plays an essential role in enhancing expression, critical thinking, and logical thinking. Moreover, it is a motivational tool that encourages learning and creative thinking (Alsumait and Al-Musawi 2013; Wang et al. 2013). In order to understand children's views, creating new stories, events and characters and then telling them are important activities (Ryokai and Cassel 1999). When children narrate a story, they state their thoughts and views about each other (McCabe and Bliss 2003 cited in Petersen et al. 2008). Also, they use their own sounds and can look at text and pictures in a book and turn the pages while narrating. This is a traditional way of storytelling (Zhou et al. 2004a).

Today, interactive media can be embedded in stories and interactive stories have emerged. As storytelling is influenced more and more by technological developments, researchers have begun to focus on computer-supported storytelling systems, including the creation of interactive stories, conceiving flexible story contexts, and designing a decision-making process (Wang et al. 2008, 2013). Similarly, schools have a tendency to prefer interactive storytelling activities over traditional methods (Chu et al. 2013).

Interactive storytelling is a story creation process involving the use of media. In this process, a narrative is presented by the users (Cavazza et al. 2007). They can use images, music, and sound to add dynamics to the story (Chung 2007). In interactive storytelling systems, children fictionalize their stories, the system records their voices and movement, and then the story is acted out (Fridin 2014). Technological tools provide more interaction and stimulate the imagination of children by improving the storytelling experience (Kara et al. 2014). When compared to traditional storytelling activities, interactive storytelling brings more alternatives in developing stories, enhances storytellers' imagination and creativity (Stapleton et al. 2002), and provides educators with a range of options that facilitate learning using interactive tools (Alsumait and Al-Musawi 2013). Interactive storytelling is mainly about engaging, enjoying, stimulating, creating, and collaborating and is essential for the new generation sometimes referred to as digital natives (Alsumait and Al-Musawi 2013). In the literature, many studies have been focused on

interactive storytelling. They create new interactive systems and set out to investigate their effectiveness. Related studies on interactive storytelling are presented in Table 1.

As we can see from the literature, interactive storytelling provides us with many benefits. Raising the level of creative thinking, critical thinking, effective communication ability, and logical thinking (Alsumait and Al-Musawi 2013; Wang et al. 2008, 2013) all serve to confirm that storytelling is, in a way, too important for education. Also, it can be clearly observed that storytelling supports the cognitive, social, and affective development of a child (Ryokai and Cassel 1999). Furthermore, storytelling, an enjoyable experience (Kara et al. 2013; Wang et al. 2008), involves abilities such as problem solving, thinking, commenting, analyzing, and synthesizing (Garzotto and Forfori 2006; Wang et al. 2008, 2013). It also aids the development of language abilities, including the learning of foreign languages, and facilitates self-expression (Alsumait and Al-Musawi 2013; Ryokai and Cassel 1999; Wang et al. 2008, 2013; Wright 1995). While storytelling can contribute greatly to children's growth (Ryokai and Cassel 1999), it also develops their ability to control their own learning and motivation, increases their desire for cooperative studying, develops their planning and monitoring abilities, and enhances their imaginations (Alsumait and Al-Musawi 2013; Cassell 2002; Malcolm 2002; Wang et al. 2008, 2013; Wright 1995). Taking into consideration all these contributions, for this study a different interactive storytelling system has been created and its effects on students have been examined.

1.3 Creativity in stories

Creative thinking is defined as solving problems by introducing a new product and becoming sensitive to its challenges (Torrance 1966, 1968). Creativity is deducing new ideas while looking at the same issues. It requires original thinking and the creation of different connections. It is not only a skill that each individual can have but also a feature that can degrade or be developed over time. Teaching and learning methods are very important for stimulating creativity. To develop it, students' activeness and the integration of creative thinking into education are necessary (Akcam 2007). With the help of developments in education systems, learning activities have been reformed and more motivational and creative activities have been introduced to the syllabus rather than rote learning activities (Chen 2006). Furthermore, the process has been improved through new technologies which incorporate many activities that contribute to students' creativity (Wang et al. 2008). Storytelling, one of the activities included above, has turned into interactive story activities with the help of technology, supporting children's imagination and creativity through sound, graphic and other multimedia elements (Meltz 1999 cited in Cassell and Ryokai 2001). Interactive stories have become highly regarded for their

Table 1 Studies on interactive storytelling systems in literature

Interactive story creation system	Aim/scope	Resources
Story mat	A system contains stories along with creative objects, vocabularies, and idioms capturing attention with the help of toys	Ryokai and Cassel (1999)
Magic story cube	Listening activities supported with 3D graphics and foldable cube systems	Zhou et al. (2004b)
EVE	A system designed to help children to learn how to read and write and motivate them	Popovici et al. (2004)
TellTale	A system designed to help children to tell stories with using modular toys	Ananny and Cassell (2001)
TOK	A system which enables children recreate the story defined with using different parts and different pictures	Sylla et al. (2011)
StoryRooms	A system working with sensors designed for enabling children to create and organize a story with symbolic objects	Montemayor et al. (2004)
ToonTastic	A system that enables children to create stories with their own cartoon characters and share it	Russell (2010)
PuzzleTale	A story creation system integrated into jigsaw puzzles and enables children to be formed in different characters	Shen and Mazalek (2010)
TellTable	A story creation system, multi-push interaction system, enabling children to create stories within the framework of children interaction	Cao et al. (2010)
CAVE	A story creation system in which 3D animation characters' poses and voices created in virtual worlds	Cavazza et al. (2007)
SAGE	A system enabling children to vocal their own emotions and form interactive stories	Bers and Cassell (1999)
KidPad	A system enabling children to create stories bounding their own drafts, which they draw in 2D environment	Hourcade et al. (2002)

entertaining features, contributing to imagination and creativity (Alsumait and Al-Musawi 2013; Sugimoto et al. 2009; Wang et al. 2013). In addition to these, storytelling activities have grown in popularity with the help of AR technology, demonstrating their high potential for increasing creativity and imagination (Klopfer and Yoon 2004).

Creativity in stories is closely related to individual imagination. The more imagination and description used in a story, the more creativity occurs. In addition, using imaginative objects is important factor for creativity. However, no one specific scale has become established for determining levels of creativity in stories (Lee 2005), and researchers have used a variety of different methods in the past. Sheldon and Rohleder (1995), Cassell and Ryokai (2001), Howe and Bruno (2013) and Kara et al. (2013) analyzed a number of imaginative objects. Imaginative objects are defined as fantasy objects that children transform into realistic objects (Sheldon and Rohleder 1995). For example, when a child uses a house as a school, the house represents an imaginative object (Kara et al. 2013). Similarly, when a child uses a drinking cup as a magic wand, the drinking cup is an imaginative object (Sheldon and Rohleder 1995). Another method used for assessing creativity is to analyze descriptive words, such as "blue house," "brown road" or "magic tree" (Cassell and Ryokai 2001). Howe and Bruno (2013) calculated the total number of adjectives as well as the number of unique adjectives. Descriptive language may be an important factor because it enriches the narrative and reflects creative use of language. Although the literature on children's use of adjectives is limited, suggestions have emerged that it is associated with creativity (Howe and Bruno 2013). Maloney and Hopkins (1973) stated that written narratives that include more adjectives are more creative than those with fewer. To sum up, creative stories can be defined as stories rich in adjectives, covering many descriptions and full of imaginative objects. For this reason, the number of imaginative objects used, overall adjective use, and the range of different adjectives were used to analyze creativity in the stories in this study.

1.4 Related studies

When researching AR and storytelling in the literature, we discovered various studies on interactive storytelling systems (Grasset et al. 2008; Dünser and Hornecker 2007a; McKenzie and Darnell 2003; Saso et al. 2003; Wang et al. 2013), interactive robot storytellers (Fridin 2014), and foldable systems and story cubes for storytelling (Juan et al. 2008; Zhou et al. 2004a, 2008). The results showed that children have a positive attitude toward storytelling (McKenzie and Darnell 2003) and enjoy storytelling activities (Grasset et al. 2008), especially those with 3D graphics and sound (Zhou et al. 2004a). Dünser and Hornecker (2007b) stated that children like AR storytelling systems because they interact with the story characters by moving paddles. Children in the studies suggested that interactive storytelling activities were more enjoyable (Fridin 2014; Juan et al. 2008), easier to use, and more inspirational than traditional activities (Wang et al. 2013). A summation of studies involving both AR and storytelling activities is presented in Table 2.

2 Method

2.1 Research design

Posttest-only design with a nonequivalent group model was used, which is appropriate for comparing two or more groups without a pretest or random assignment (Cook et al. 1990). Quasi-experimental methods cover many models within themselves. In this study, the nonequivalent comparison groups posttest model has been used (Fig. 1). This model is suitable for comparing results on condition that the researcher intervenes in two or more groups. There is no need for pretest or random assignment (Cook et al. 1990). Some researchers (McMillan and Schumacher 2010) state that this method should be mentioned under the headline of pre-experimental methods; however, some others accept it as in quasi-experimental methods in the literature (Cook et al. 1990). Researchers who evaluated it as a pre-experimental method argue that there is no pretest application. Therefore, it cannot be covered within quasi-experimental methods. On the other hand, researchers accepting it as a quasi-experimental method state that each study has a unique framework and it cannot be appropriate for pretest applications. According to them, having similar characteristics and being at the same level are the main properties of a group. Departing from that, as pretest is not a priority and the research is conducted within the same age group, the research method has been categorized as a quasi-experimental method. A quasi-experimental method is a method used for comparing groups without any random assignment to the experimental and control groups. This method is an alternative used in circumstances where full experimental methods are inappropriate (Fraenkel and Wallen 2000; McMillan and Schumacher 2010).

2.2 Sample

In this study, 100 fifth-grade elementary students (10–11 years old), comprising 46 boys and 54 girls, were divided into two groups. The experimental group

Table 2 AR and storytelling activities studies

Authors	Aim of the Study	Results
Fridin (2014)	To explore student performance and interaction levels during robot-supported storytelling	Students enjoyed it and performed at high levels
Grasset et al. (2008)	To get participants' opinions about developed storytelling activities	Participants liked it
Dünser and Hornecker (2007a)	To observe students reading and interacting with AR story books	Students expected experiences to mirror real life
Dünser and Hornecker (2007b)	To examine interaction with AR storytelling activities	Children mostly enjoyed the moving story's characters and objects
Juan et al. (2008)	To determine differences between head mounted display systems and computer monitors	No differences were found. Also, participants enjoyed the experience
McKenzie and Darnell (2003)	To develop and evaluate a story book	Participants had a positive attitude toward the story book
Saso et al. (2003)	To simulate the story of Little Red Riding Hood by using a head mounted display system	The results presented the story's development process
Wang et al. (2013)	To examine the effectiveness of StoryCube, a 3D storytelling system	The storytelling system was enjoyable and easy to use
Zhou et al. (2004a)	To develop a foldable storytelling system using a head mounted display system	The system was made attractive and understandable by means of 3D graphics
Zhou et al. (2008)	To examine the transmission of data and get opinions about two StoryCube applications	The application was appreciated and effective in the transmission of data

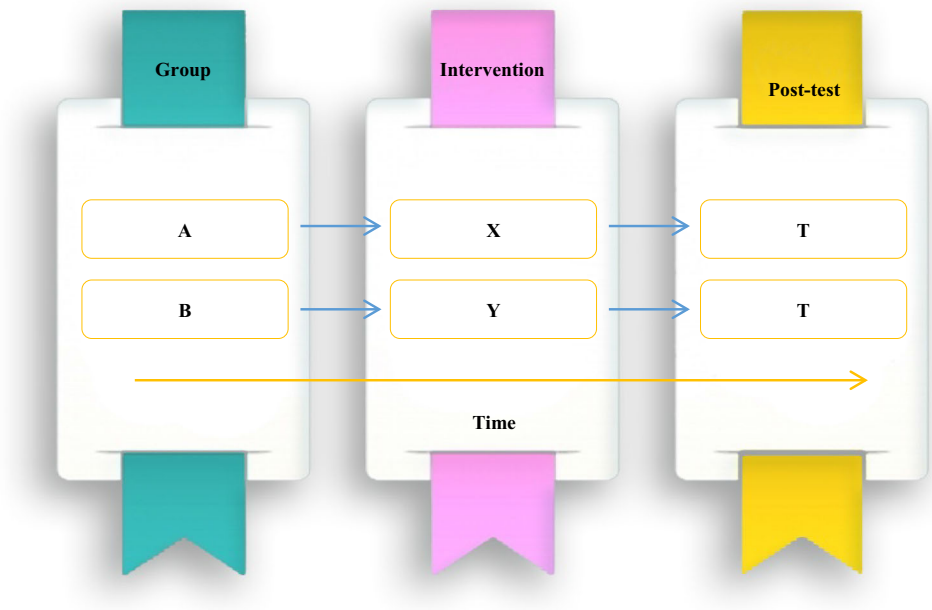

Fig. 1 Research model for this study (A, B = simulated groups, X, Y = different interventions applied, T = applied test)

included 50 students from classes A and B, and 50 students from classes C and D made up the control group. Students who did not volunteer were not included. None of the students in either of the groups had used AR applications before, and none was familiar with storytelling activities. However, as part of the curriculum determined by the Ministry of Education, students had been using traditional storytelling activities for 2 years, beginning in third grade. Therefore, they were experienced in traditional storytelling. It was seen that rich storytelling activities existed at the third, fourth, and fifth grade levels in the elementary school curriculum. Fifth-grade students were selected for the study because they were expected to have stronger expression skills, they were experienced in storytelling activities, and the curricular activities were appropriate for AR

applications. Two teachers also indicated that fifth grade would be a good fit for our activity.

With regard to sampling, purposive and convenience methods were applied: For purposive sampling, the group's ages, education levels, and experiences in storytelling activities were gathered, and for convenience sampling, easy access to schools was considered. In this study, the purposive sampling method has been chosen, taking into consideration the ages and levels of education of students, their experience levels and the fact that previously they were participants in storytelling activities framed within the Ministry of Education curriculum. Pre-interviews were conducted with teachers and classes were chosen, taking the factors mentioned above into consideration. The convenience sampling method was used to determine the pilot school to be used for the research.

2.3 Research process

The research process consisted of five steps: analysis, design, development, implementation, and evaluation (see Fig. 2). In the analysis process, different grade levels in elementary schools were examined. Next, the story's main theme of friendship was drawn from the textbooks. Finally, the necessary tools for marker-based AR were identified. The BuildAR program was selected due to its ease of use. During the design process, an activity was developed for determining 3D objects. A group of 40 fifth-grade students wrote down five objects related to friendship. Words repeated at least twice were selected for the activity (see Table 3). In addition, six characters were introduced (a girl, a boy, a man, a woman, an old man, and an old woman), and three backgrounds (a grassy background, a stony background, and a coast), based on the recommendations of two experts. Totally 24 cards and three backgrounds were used for implementation.

After the 3D objects were decided on, markers were designed. Both 3D and 2D objects had the same design. A black and white design was used for markers because the web camera detected them best. During the development process, all designs were further refined and enhanced. Samples of the materials developed are presented in Fig. 3. During the implementation phase, a pilot study was conducted with six students to identify and correct problems.

Next, students in both groups created stories about friendship. While the experimental group created stories with AR cards (see Fig. 4), the control group did not. In the experimental group, students using AR cards set up their stories by selecting characters and objects (at choice) and viewing their displays on a computer monitor. AR technology provided students with the facility to display 3D characters and objects on black and white cards. Students did not develop any AR applications themselves. They only used the AR cards developed by the researchers. The control group used only story cards to create their stories. They selected some characters, object cards (at choice), and used them in their own way. They told their story against a background using their chosen cards without viewing their 3D display. A specific protocol was followed in order to equalize all conditions. All activities were implemented in the same classroom. First, a story map activity was presented to all students featuring questions such as, "Who is the most important character in your story?" and "When did the events occur in the story?" The experimental groups played with the program's options before the storytelling activity for approximately 15 min before they were introduced to the AR application. This procedure was followed to ensure the program was easy to use for the students. Then, both groups were instructed to create stories using their preferred cards (characters and objects) and backgrounds. All activities in both groups were recorded with the Camtasia Recorder 8.0 and a video camera. Students created stories lasting from 1.5 to 6 min. Total 100 students' storytelling records of a total of 100 students were collected over a period of 4 weeks. Finally, the students' stories were assessed for narrative skill and creativity. The evaluation was conducted by a researcher who viewed all the tapes after completion of the implementation, before carrying out a full transcription of the students' stories.

2.4 Data collection tools

In this study, two forms were used as data collection tools. The first, the index of narrative complexity (INC) (Petersen et al. 2008), includes categories for rating the complexity of characters, setting, initiation of events, internal responses, plans, action/attempts, complications, consequences, narrator, formulaic markers, temporal markers, and causal adverbial clauses. The INC developed by Petersen et al. (2008) was used without the requirement for any changes. It consists of 13 items. With regard to the grading of the items, each item has a score between 0 and 3 points, and a total score has been calculated for each individual. Also, the length of each story was integrated into the evaluation since it is a significant predictor for narrative skill (Dillon and Underwood 2012; McConnell 2011; Reilly et al. 1998; Wagner et al. 1999). All stories were evaluated with this tool.

The second data collection tool, the Creativity in Stories Form, was developed by the researchers based on Howe and Bruno (2013), Sheldon and Rohleder (1995), Cassell and Ryokai (2001), and Kara et al. (2013). According to their studies, the quantity of imaginative objects, the overall number of adjectives used, and the number of

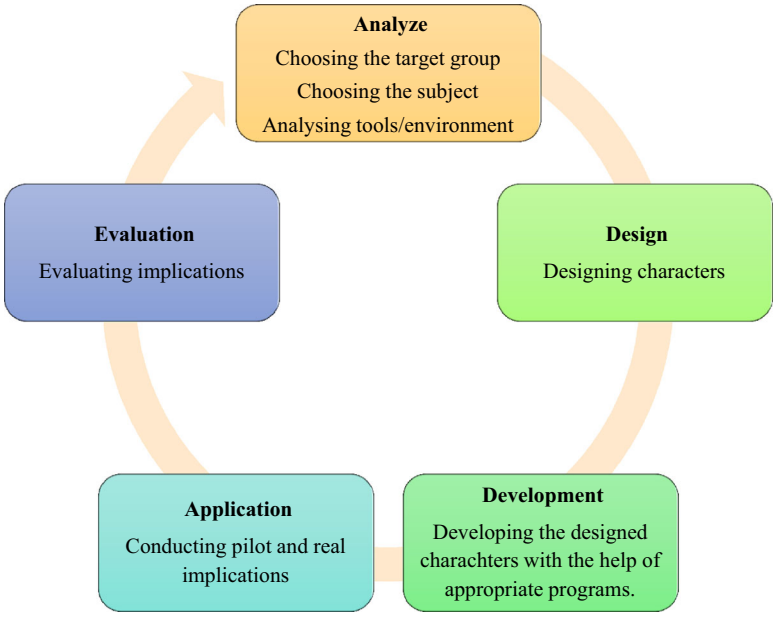

Fig. 2 Research process

different adjectives used are important when analyzing creativity in stories, so these constitute the basis of the form. In order to determine levels of creativity in stories, the scores for each factor were counted separately and total scores were taken into consideration. This may seem a little obscure and limited but these are the only variables to determine creativity in stories that we were able to access from the literature. While developing this form, first we reviewed the literature. Three Ph.D. experts were fully briefed in terms of the study's aim, content and sampling. The numbers of imaginative objects, overall adjectives, and different adjectives were selected from different studies. Therefore, we used a correlation test in order to evaluate whether these variables were related to each other or not. The results of the test showed that all variables related to each other ($p < .05$). Finally, the experts authorized the final version of this form.

For the INC's validity and reliability, a language expert translated the survey scale into Turkish from its original language, English. Another language expert verified the translated scale. With regard to the validity and reliability of the Creativity in Stories Form, an evaluation form was produced after reviewing the literature. The "number of adjectives," "number of different adjectives" and "number of imaginative objects" were determined for each individual, and the total number was calculated. Three field experts analyzed and approved the data as appropriate for statistical analysis. Also, all data collection tools and the overall research process were verified by three experts in terms of sampling, research aim, and scope. To determine inter-rater reliability, two experts evaluated 15 students' data, and the results were examined with a correlation test. High positive correlations were found for both measurements ($r_{\text{narrative skill}} = .909$, $p < .01$; $r_{\text{creativity in stories}} = 1.000$, $p < .01$).

Table 3 Friendship-themed objects recorded by students

Pictures	Words	f
	Gift	16
	Heart	12
	Flower	12
	Book	11
	Letter	9
	Toy	7
	Ball	6
	Computer	5
	Cake	4
	House	4
	Cat	3
	Tree	3
	Balloon	3
	Chocolate	2
	Fish	2
	Ice cream	2
	Dog	2
	Table	2

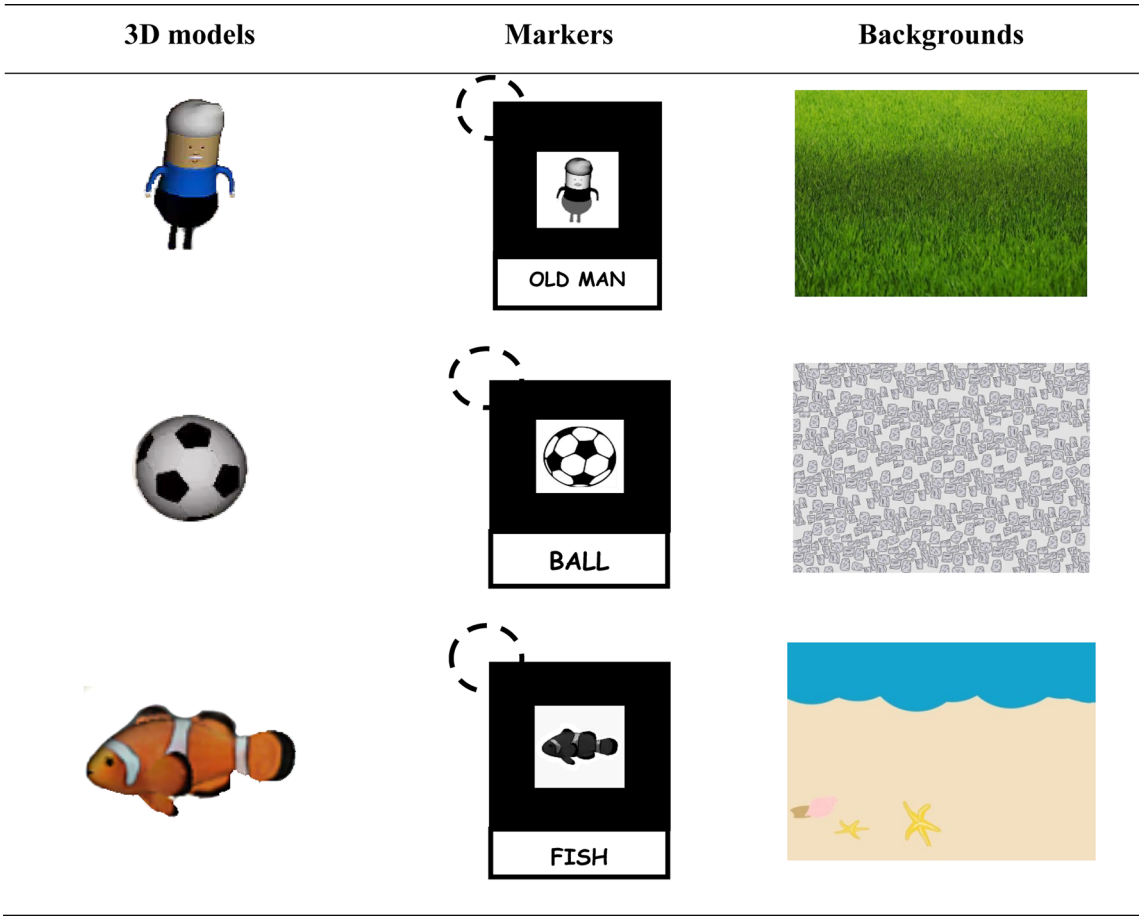

Fig. 3 Samples of designed 3D models, markers, and backgrounds

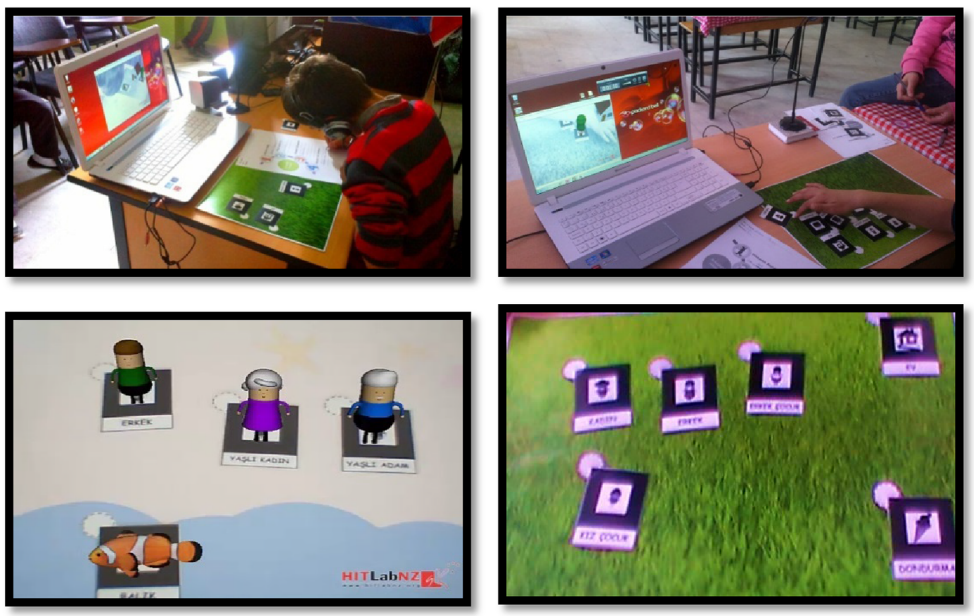

Fig. 4 Screenshots and images of storytelling activities

2.5 Data collection process

The procedure for the data collecting process is as follows in Fig. 5.

2.6 Data analyses

All data were analyzed by document analysis. Missing analyses and normality tests were conducted. While the data for narrative skill had normal distribution, the other data had positively skewed distribution; logarithmic transformation was applied, and normality tests were conducted again. Consequently, all data presented normal distribution. A one-way MANOVA and multiple correlation tests were then used. To ensure the assumptions of the MANOVA, sample size, normality, outliers, linearity, multicollinearity and singularity, and homogeneity of variance were tested before analysis (Pallant 2005). Results of Box's M Test of Equality of Covariance Matrices showed no violation of the assumption ($p = .13$). All significance values ($p_{\text{length of stories}} = .45$, $p_{\text{narrative skill}} = .33$, $p_{\text{creativity in stories}} = .23$) in Levene's Test of Equality of Error Variances were more than 0.05. For multiple correlation tests, all assumptions were confirmed.

3 Findings

3.1 Students' narrative skill, length of stories, and creativity

According to the descriptive findings, mean scores for narrative skill, length of stories, and creativity in stories for the experimental group were higher than for the control group. Also, girls in both groups presented a high average, except with regard to the number of imaginative objects. Detailed findings are shown in Table 4.

3.2 Differences between experimental and control groups

A one-way multivariate analysis of variance was conducted to examine the effects of AR technology on students' narrative skill, length of stories, and creativity in stories. Wilks's lambda (Λ) was applied to meet all assumptions (Tabachnick and Fidell 1996). The results revealed a statistically significant effect on the dependent variables ($\Lambda = 0.756$, $F_{(3,96)} = 10.32$, $p = 0.00$). The partial η^2 value was 0.24, indicating that 24 % of the multivariate variance of the dependent variables was explained by the group. Detailed findings are presented in Table 5.

As shown in Table 6, a statistically significant mean difference was found between the experimental and control groups regarding narrative skill, length of stories, and creativity in stories. With respect to length of stories [$F_{(3,96)} = 4.19$, $p = 0.04$, $\eta^2 = .041$], the mean scores of the experimental group were higher ($M = 172$, SD = 80.33) than those of the control group ($M = 146$, SD = 64.67). In other words, the experimental group created longer stories, and the group explained 4.1 % of the variance in length. For narrative skill [$F_{(3,96)} = 20.77$, $p = 0.00$, $\eta^2 = .175$], the mean scores of the experimental group were again higher ($M = 19.92$, SD = 3.40) than those of the control group ($M = 16.66$, SD = 3.21). The experimental group created better stories, and the partial η2 value indicates that the group explained 17.5 % of the variance in narrative skill. For creativity in stories [$F_{(3,96)} = 12.75$, $p = 0.01$, $\eta^2 = .115$], the mean scores of the experimental group once again had a higher value ($M = 22$, SD = 12.70) than those of the control group ($M = 13$, SD = 9.15). The experimental group wrote stories that were more creative, and the partial η^2 value indicates that the group explained 11.5 % of the variance in creativity in stories.

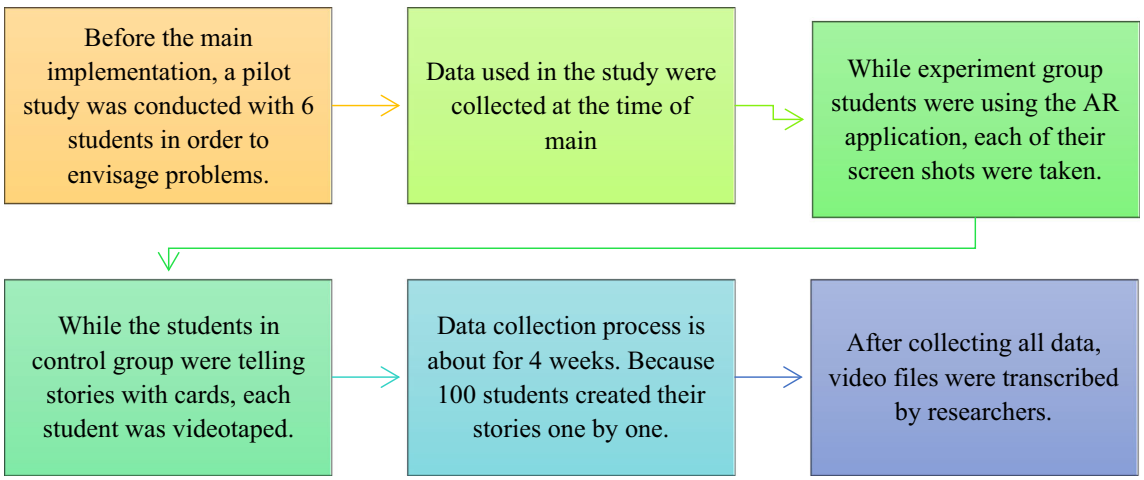

Fig. 5 Data collection process

Table 4 Descriptive findings

	Experimental group				Control group			
	Girls ($N = 25$)	Boys ($N = 25$)	Total ($N = 50$)		Girls ($N = 29$)	Boys ($N = 21$)	Total ($N = 50$)	
	M	*M*	*M*	SD	*M*	*M*	*M*	SD
Length of stories (counted words)	173	170	172	80.33	157	130	146	64.67
Narrative skill	20.00	19.84	19.92	3.40	16.86	16.38	16.66	3.21
Creativity in stories								
Total number of adjectives	14	13	13	9.16	10	7	7	6.62
Number of different adjectives	6	7	7	3.16	5	4	4	2.46
Number of imaginative objects	2	2	2	1.65	2	2	2	1.30
Total	22	22	22	12.70	17	13	13	9.15

Table 5 MANOVA results on collective dependent variables by group

Source	Wilks's Lambda	*F*	*p*	R^2
Intercept	.004	7765.90	.000	.996
Group	.756	10.32	.000	.244

3.3 Correlations between length of stories, narrative skill, and creativity in stories

The Pearson correlation test was used to determine correlations between length of stories, narrative skill, and creativity in stories. A positive correlation was found between all variables, and detailed findings are presented in Table 7.

4 Discussion

The current study examined the effects of AR technology on elementary students' stories with regard to narrative skill, length, and creativity, as well as the correlations between these variables. First, students' narrative skill and story length were determined for both the control and experimental groups. The results revealed that students using AR created better stories, similar to the findings of Ryokai and Cassel (1999). One of the reasons for this finding may be the use of 3D objects in the stories. Kim et al. (2013) stated that AR technology is an appealing application for interactive storytelling when used with 3D objects. Similarly, Zhou et al. (2004b) found that using 3D objects with AR makes storytelling activities more attractive and easier to understand. In this way, the activity becomes more exciting and fun. Another reason for this finding may be using 3D characters. Dünser and Hornecker (2007b) found that controlling and interacting with story characters through the movement of paddles can enhance students' level of engagement with the story. According to them, this connection with story characters can provide a particularly positive contribution when creating a story. Kara et al. (2013) observed that generated cartoon characters have a significant positive effect on children. Telling a story with familiar characters facilitates understanding and heightens the experience for children (Ryokai and Cassel 1999). In addition, students' narrative skill level was high because AR storytelling is an attractive, exciting, and fun activity in its own right as well as for the reasons above.

Table 6 Differences between dependent variables

Source	Dependent variable	Sum of squares	Mean square	*df*	*F*	*p*	R^2
Corrected Model	Length of stories (counted words)	.126	.126	1	4.19	.043	.041
	Narrative skill	.158	.158	1	20.77	.000	.175
	Creativity in stories	1.042	1.042	1	12.75	.001	.115
Intercept	Length of stories (counted words)	468	468.280	1	15,538.54	.000	.994
	Narrative skill	156.872	156.872	1	20,563.75	.000	.995
	Creativity in stories	145.056	145.056	1	1775.39	.000	.948
Group	Length of stories (counted words)	.126	.126	1	4.19	.043	.041
	Narrative skill	.158	.158	1	20.77	.000	.175
	Creativity in stories	1.042	1.042	1	12.75	.001	.115

Table 7 Correlations between all variables

	Length of stories	Narrative skill	Creativity in stories
Experimental group			
Length of stories (counted words)	1		
Narrative skill	.735**	1	
Creativity in stories	.658**	.319*	1
Control group			
Length of stories (counted words)	1		
Narrative skill	.643**	1	
Creativity in stories	.632**	.347*	1

* $p < .05$; ** $p < .01$

Another result revealed that students who created stories with AR wrote longer stories. This result can be explained by students' increased engagement. As we know, technology-supported storytelling systems hold the attention of students over an extended period of time (Kara et al. 2013). Rich content, 3D objects, and cartoonish characters may also affect students' engagement level and story length. Aziz et al. (2012), Keedy et al. (2011) and Pinhanez et al. (2000) have all supported this claim. In addition, AR technology has an important role to play in encouraging students to write longer stories. In one study, children described AR as "magic" because it can transform something out of a fantasy book into reality (Billinghurst et al. 2001). This effect can elicit a high degree of surprise and curiosity in users (Bujak et al. 2013), indicating it is an important factor for engagement and the creation of longer stories.

In this study, students' storytelling creativity was examined for both groups. The total number of adjectives, the number of different adjectives, and the number of imaginative objects were determined, and the result revealed that the children who used AR made more creative stories. This group used more adjectives overall and used more different adjectives. Both interactive storytelling and AR technology may affect this result, as they both foster children's creativity and imagination (Klopfer and Yoon 2004; Stapleton et al. 2002). Also, students using AR can see their story characters and their objects' colorful 3D displays on a monitor. This may encourage them to tell what they see and to use many descriptive expressions which include adjectives.

It has been observed that, in both the experimental and control groups, there is a significant relationship between the length of students' stories and their narrative skill and creativity in telling stories. The relationship between story length and story creation ability can be explained by the expression of stories in detail and profound descriptions of events and characters. Thus, in analyzing a story, character, environment, starting events, character's psychology, planning, event, conflict/complexity, end of the story, stereotyped expressions, time expressions, reason and result adverbs, dialogues, and narrator's comments are all taken into consideration (Petersen et al. 2008). Stories which fully encompass all of these factors are likely to be longer. The relationship between story length and story creation ability can also be explained by the fact that longer stories tend to use vocabularies which are more descriptive in themselves. It is widely accepted that descriptive expressions such as the use of adjectives in stories promote story creativity (Howe and Bruno 2013). The relationship between narrative skill and story creation ability can be explained by the richness of the characters in the stories, the environment in which the story takes place, the start and end of the story, and complexity all combine with the children's' imagination. Furthermore, the act of children creating stories with their own imagination promotes the development of more creative stories (Kara et al. 2014). Providing children with computer-based dynamics, as well as a wide range of choices, gives them opportunities to create richer stories. In this regard, children can create richer and more creative stories by using their imagination (Cassell and Ryokai 2001; Kara et al. 2014). It is evident from this study that giving children opportunities to create their own stories with their own imagination contributes to their creativity. In this study, the students in both conditions (whether using AR or not) were given opportunities to create their own stories with their own imagination. The main conclusion of the research is that students using AR technology are more creative than the others.

4.1 Limitations

Posttest-only design with a nonequivalent group model was used in this study. Using no pretest can be seen as a limitation. Every study has a unique framework, and it is not always appropriate for pretest applications. Having similar features and being at the same level are the main characteristics of a group. Aside from this, as pretest is not a priority and the research was conducted within the same age group, we did not carry out a pretest.

5 Conclusions and suggestions

In this study, students' narrative skill, length of stories, and creativity in stories were investigated. Students who used AR earned high scores for all variables with a positive correlation between each of them. This study is limited to data obtained from 100 fifth-grade students. A larger sample size and wider range of grade levels may be used to expand on these findings. AR may be especially effective with students in early childhood. To obtain more reliable data and to eliminate novelty effects, the implementation process should be longer. In this study, one expert analyzed the data. To eliminate bias, two or more experts should evaluate all the data. Because the criteria for creativity in stories were limited in this study to the total numbers of adjectives, different adjectives, and imaginative objects, other factors could be added to enhance the overall assessment. Lastly, this study was based purely on quantitative research, and it is likely that the addition of qualitative data to the mix may produce even richer data. For future research, the cognitive process of students' thinking may be a fruitful area for investigation and, because results could be affected by level of engagement, in this context engagement is another aspect which could benefit from further examination.

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