Using digital storytelling for teaching the subtraction algorithm to 2nd grade pupils

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Abstract

The paper reflects on a teaching intervention which utilized digital storytelling as an approach for teaching the subtraction algorithm in 2nd Grade. Literature indicates that this is a difficult topic for children of this age. The aim was to examine if through digital storytelling, students find it easier to understand and apply the two subtraction algorithms which are described in the official textbook, namely the "Borrow First and Then Subtract" and the "Austrian Subtraction" algorithms. The results indicate the effectiveness of this approach is, further enhancing the existing literature on the topic.

Keywords: Digital storytelling, mathematics, primary education, subtraction

Introduction

It is widely accepted that mathematics as a disciplinary area often causes discomfort to students in all levels of education, although their usefulness for everyday activities is overall recognized. Research indicates that even high-achieving students consider mathematics a tedious subject (Ignacio et al., 2006). Furthermore, frequent failure often leads to an enhanced negative attitude towards the subject. Chapman (1988) discussed that it is difficult for students to accept that a possible failure to solve a mathematical problem reflects on their own ability, while attributing success to various factors, including luck. This way, a feeling of inferiority and a negative attitude students towards mathematics is gradually built from their side.

The vertical subtraction algorithm is often executed incorrectly by young students. These erroneous executions are wrong variations of the correct algorithm which are mentioned in the literature using the term "bugs" (Lemonidis, 1994). They occur when a person who has understood an algorithm, or not, encounters a dead end, either because he/she has forgotten the solution process or it turns out that eventually he/she has not learned the approach correctly or even at all. In this case, instead of interrupting the resolution, the individual tries to reconstruct a solution, which may be more or less far from the correct algorithm. Therefore, the didactic approach to this subject is a key question, even for contemporary research.

Digital Storytelling is a contemporary research trend, incorporated in the educational practice over the last decade. It is a form of art which combines multimodal elements (e.g. images, sounds, videos, text, and recorded narration) for the construction of a short story (Robin & Macneil, 2012). The produced stories, usually in the form of short videos or digital comics, are utilized in all levels and disciplinary areas of education, in various ways (Bratitsis, 2017). There is intense research activity over the past few years regarding the utilization of digital storytelling for teaching various school subjects, especially in younger ages (Bratitsis, 2014; Roussi & Bratitsis, 2017; Savvopoulou & Bratitsis, 2017; Bratitsis et al., 2017; Bratitsis & Prapas, 2018; Bratitsis & Mantellou, 2019). Most of the studies of this kind in the literature which were conducted in real school settings have been carried out in Greece, as it is not uncommon to implement such interventions in real school settings.

This paper describes a teaching intervention which utilizes digital storytelling for teaching mathematics in Primary School. Specifically it regards the two vertical subtraction algorithms which are taught in the 2nd Grade, according to the official Greek curriculum. The paper is structured as follows: initially the theoretical background is developed. Then the research methodology is presented along with the teaching intervention which took place in various occurrences. Lastly, the results are presented, leading to the concluding discussion.

Theoretical Background

In this section, the theoretical pillars of the paper are discussed. The first one is about Mathematics in Primary School, focusing on the selected topic, that of teaching the vertical subtraction algorithm in two variations. The other is that of Digital Storytelling and its utilization in Education.

Mathematics and storytelling in Primary School

Mathematics Education increasingly focuses on the cultivation of positive attitudes and perceptions about mathematics, as well as experiencing positive emotions by the students when they are engaged in math-related activities (McLeod, 1992). The most common attitude of children towards mathematics is described by the term *math anxiety* or *mathphobia* (Lazarus, 1974; Tobias, 1993). According to Moses (2001), teaching of mathematics which is based mainly on memorization and not on understanding through discovery, often causes abomination for the subject. Thus, the negative attitude towards it is further enhanced.

Narration (referring to using and reading out stories) seems to be one of the means proposed to address this peculiar relationship of students and mathematics. It is argued that through stories, children can better understand abstract mathematical concepts while cultivating a range of other skills (Miller, 2002). Stories can help them develop the ability to predict the solution of a problem, just as they do at the point of climax within a story-plot, where the reader has the opportunity to predict the outcome of the story. Following Dewey's approach, Kokkotas et al. (2010) report that prediction leads to the development of romantic understanding which contributes significantly to the conceptual understanding of difficult concepts and therefore students should have sufficient opportunities to gain the experience of prediction. This way, they will be able to solve mathematical problems.

In the same vein, Vygotsky (1998) studied imagination and how it relates to narration, arguing that its development enhances the activation and development of abstract thinking. The latter leads to an increased likelihood of understanding abstract concepts in Sciences (Kokkotas et al., 2008). According to Vygotsky (2004), imagination is a way to know the world through various resources (e.g. books, narrations, pictures). He describes an internalization and an externalization process while an individual learns. Internalization is described as a process of storytelling for explaining the world to oneself, whereas externalization is a process of storytelling for explaining the world to others while interacting with them. In both cases, narration holds a key role in learning for manipulating and understanding abstract issues and phenomena, but also meaning-making.

Storytelling has been examined as means of teaching various mathematical concepts. For example, Casey, Kersh & Mercer-Young (2004) proposed the utilization of problem-solving adventure stories for K-2 mathematics teaching. Casey et al. (2008) contextualized geometry teaching in Kindergarten via storytelling, incorporating puzzle-like adventure problems. Zazkis & Liljedahl (2009) designed a framework for deploying storytelling for teaching mathematics in Primary Education in an interactive way which incorporates the creation of learning spaces within a classroom. Pramling & Samuelsson (2008) approached basic mathematics through storytelling when working with 6 year old students. Similarly, Wessman-Enzinger & Mooney (2014) worked on the concept of integers through storytelling. The aforementioned studies are just a sample of work on the utilization of storytelling for

teaching mathematics. Of course there are many more, including mathematics teaching in higher levels of education and also in other contexts (e.g. STEM Education).

In traditional approaches, the teacher entirely represents the knowledge source for mathematics. Common practices concern a repetitive examination of the learning material and continuous practice. Over the last twenty years though, there has been a shift in the corresponding approaches. The specific goal of teaching Mathematics in Primary School, as defined by the official Greek Curriculum, focuses on examining mathematics with a not so mechanistic approach and an understanding by the children of the multifaceted (communicative, reasoning, discovery, etc.) value of mathematics and of cultivating a positive attitude towards them (Kargiotakis et al., 2006).

Nowadays, mathematics aims to become meaningful for children (Van de Walle, 2005). Understanding in the context of mathematical education is investigated from different perspectives and is an integral part of mathematics teaching (Koleza, 2000). Understanding concepts within multiple contexts (conceptual understanding) facilitates knowledge building and has multiple benefits for students (Van de Walle, 2005). Storytelling based approaches seem to address exactly these aims, as storytelling relies on meaning making and message conveyance (Bratitsis, 2017).

The subtraction algorithm

The term algorithm describes the mechanical process in which predefined steps are sequentially executed. In order to execute the algorithm of an arithmetic operation, one is required to know the individual simple operations required for performing this task. Therefore, simple operations are included in the algorithms of the corresponding operations (Lemonidis, 1994). In arithmetic operations, the term algorithm is widely used to describe fixed, written, computational, but also mental processes for performing an operation.

Specifically, in the subtraction algorithm it is necessary to know the value of each digit's position and the basic combinations of subtraction. Subtraction without borrowing is the easiest form and does not seem to be difficult for students. When numbers have more than one digit, the algorithm becomes more difficult since borrowing of a higher value digit is often required. Greek school textbooks nowadays refer to "genuine borrowing" (borrowing of a higher value digit) and the "addition of equal amounts" (addition of the loan digit to the diminutive and the deductible). In the literature they can be found with the terms "Borrow First and Then Subtract" and "Austrian subtraction" respectively. In order to perform subtraction with borrowing, literature reveals that students face significant difficulties (Hatzigeorgiou, 1990; Kafousi & Ntziachristos, 1998). The most common mistake is to subtract the smallest number from the largest, regardless of whether the smallest is in the minuend or the subtrahend. Also, errors are often recorded when there is zero in the deductible. Overall, the mistakes are related to the need to borrow a higher value digit in order to perform the subtraction which is then forgotten or returned in an erroneous way. There are variations of the subtraction algorithm (e.g. Borrow First and Then Subtract, Austrian Subtraction, Three Digit Algorithm, Subtract from the Base), but this paper focuses on the aforementioned two algorithms which are presented in the official textbook for 2nd Grade in Greece, as they are the ones taught to Greek students.

In the present teaching intervention, a digital story was designed to highlight the logic and the steps of the two methods and utilized in order to explore whether students can thus address the most common errors when executing this algorithm (Lemonidis, 1994).

Digital Storytelling

"Stories are more than just good for us—they are essential to survival" (Ohler, 2008, p. 9). Storytelling is one of the oldest methods of communication and learning. Stories are used to convey information or perhaps to motivate colleagues or friends (McDrury & Alterio, 2003) but also help make meaning out of experience (Bruner, 1996; Schank, 1990; Abrahamson, 1998) and convey values of a culture (Bruner, 1991). Stories also help build connections with prior knowledge and improve memory

(Schank, 1999). As a result, good stories are easily remembered (Rex et al., 2002). They express the soul of a community, its experiences and failures, the wisdom and how people have subjectively lived events, becoming a reference point for social education and enculturation (Crisan & Dunford, 2014).

Digital storytelling is the combination of traditional, oral narration with multimedia and communication tools. It is a form of art which combines different types of multimedia material, including images, text, video clips, audio narration and music, to tell a short story on a particular topic or theme (Robin & McNeil, 2012). Learning theorists claim that storytelling can be utilized as a pedagogical technique/approach effectively to nearly any subject and in all levels (Pedersen, 1995). In the case of digital stories, they can be created by teachers and/or students. As educational material, digital stories can serve as a way to present new material and capture students' attention (Robin, 2008). Furthermore, they can facilitate students' interaction and make content more understandable (Burmark, 2004). Via the internet and cloud services, students can utilize digital stories in order to express thoughts, ideas and opinions while sharing them with a wider audience. They can also improve their writing skills when creating their own stories (Gakhar & Tompson, 2007). They also become more active and productive in individual or collaborative communication activities (Bratitsis et al., 2011). With advanced technologies, digital stories can be exploited in various educational contexts following a very innovative approach (Bratitsis et al., 2017).

According to Smeda et al. (2014), digital storytelling is a modern teaching approach, which seems to enhance students' cognitive attention and activate their emotional interest. The interactive nature of narratives allows the use of technology to combine written and oral communication, in such a way as to enhance learning and comprehension and to develop critical thinking and problem-solving skills. (Moutafidou & Bratitsis, 2013; Pitler, 2006; Smeda et al., 2014).

There are two characteristic elements which distinguish digital storytelling from other similar approaches: short duration and enhanced emotional component (Bratitsis, 2017). The former results in stories of 3 to 5 minutes in most cases. The latter aims at fully engaging the recipient/viewer of the story by fully immersing him/her in it. Usually this is achieved through self-identification in the story via anchor points in it which the viewer can connect too (e.g. a main hero in a similar age or context as the viewer, an emotional reaction which can be connected with a viewer's experience etc.).

In educational settings, digital stories can be created by teachers or children (Bratitsis, 2014). In the first case, they are used as a teaching tool to present an object or a new idea in an attractive way (Robin, 2008) while at the same time facilitating the interaction of students and a better understanding of the content (Burmark, 2004). In the second case, a set of literacy skills is strengthened (Moutafidou & Bratitsis, 2013). When students create their own digital stories, they have the opportunity to express thoughts, ideas and opinions and share them with a wider audience, while improving their writing skills (Gakhar & Thompson, 2007). In addition, they become more active and productive in both individual and collaborative activities (Bratitsis et al., 2011).

In the intervention described in this paper, the first approach is followed, where the teacher uses a digital story for teaching a difficult subject in an alternative way.

Research approach

Methodology

The paper refers to a case study. A total of 74 2nd Grade students were randomly selected to participate in an experimental process involving pre- and post-test. A convenient sampling approach was followed, based on which schools replied to the authors' request for permission to visit them and implement the intervention. This was a follow-up study of a similar but smaller-scale intervention which was carried out near the end of the 2018-19 school year and incorporated a quasi-experimental approach (Bratitsis & Mantellou, 2019). This study will be referred to as Study1 hereinafter.

In Study1, the participating children were divided into an experimental and a control group. The experimental group was taught the two subtraction algorithms through a digital story (see next section) and the control group in a conventional way, following the official textbook activities. A pre- and a post-test was distributed to all participants, including a set of subtraction exercises, similar to the ones appearing in the official textbook (2-digit numbers). The results indicated that the experimental group outperformed the control group in the post-test, whereas in the pre-test their performance was similar in both groups (Bratitsis & Mantellou, 2019). This was perceived by the researchers as significant, as the experimental group only saw the digital story and didn't go through the official learning material at all. For that reason, a decision to follow the same teaching approach, utilizing the same story but with the participation of more children was made. The aim was to see if similar results would emerge, further enhancing ones of Study1.

Thus, following the approach described in the previous paragraph, all the participants completed a pre-test. Then, they viewed the digital story and were asked to re-narrate it. After 2-3 days, they were provided with a post-test to complete. Both tests included 10 subtraction exercises with 2-digit numbers in a vertical positioning. The exercises were similar to the ones of the official textbook.

The data collected were analysed in terms of the success rate of students in solving the exercises of each worksheet.

The research questions listed in the corresponding section of the paper were similar to the initial study (Study1). As already mentioned, a simpler approach was followed, in which the participants carried out the same sequence of activities as the experimental group in Study1. It is important to note that no other teaching activities were carried out, other than the students viewing the digital story between the two worksheets (pre- and post- test) which were distributed to the students with 2 or 3 days difference. The latter occurred due to the distances between the involved schools, making the attempt to distribute all the tests in the same day impossible.

Participants

The participants were 74 2nd Grade students from 3 schools in the Athens region, Greece. The study took place at the first trimester of the 2019-2020 school year.

Data collection tools

Data collection was performed using pre- and post-test, in the form of evaluation sheets. Both sheets contained subtraction exercises (10 in total on each sheet). Out of them, 6 required the use of the borrowing algorithm. These are subtractions in which the least significant digit of the minuend is smaller than that of the subtrahend and thus a decade needs to be borrowed from the directly higher digit in significance (and depending on the algorithm it has to be returned accordingly). The remaining 4 were simpler (no borrowing was required, as all the digits of the minuend were higher than those of the subtrahend). The subtractions were similar to the ones appearing in the official textbook. In addition, the researcher's entries in a diary were used.

Research aims and questions

The main research question of this intervention was, to further validate the findings of Study1 which had the following main research axis: Can Digital Storytelling be utilized in order to teach mathematics to primary school students? Specifically, can it be used to facilitate the understanding and correct application of concepts and notions that are recorded in the literature as difficult for the pupils to conceptually acquire?.

In particular, Study1 attempted to examine: a) if a digital story could be designed for effectively teaching mathematics in Primary School (specifically the vertical borrowing subtraction algorithm), b) if a digital story could be effective in presenting new knowledge, c) if the digital story could help diagnose or induce conceptual change, and d) if the digital storytelling approach can actively engage

children and provide them with an enjoyable experience. The findings were positive overall and a very interesting result emerged. That is that the digital story was used as the only teaching material and no other activities were conducted throughout the intervention. Despite that, the performance of the experimental in the post-test was rather impressive (Bratitsis & Mantellou, 2019). As one of the authors of this paper has implemented dozens of digital storytelling based studies over the past few years, this was the only one in which the teaching material included only the digital story. Thus, the findings were considered as very encouraging and this study aimed at further validating them.

The digital story

The designed story takes place in Numberland (the name is a free translation from Greek), a city in which the inhabitants are all numbers. In an apartment building live two families who play a game every day, that of subtraction. The result of is always the same (28, see Figure 1) and corresponds to the street number of the building. Through their daily play, the two borrowing methods are presented in a pleasant and descriptive way, regarding 2-digit numbers. Method A regards borrowing a unit (number 1) from the decade of the same number (decreasing it by one), allowing for the subtraction to occur as the least significant digit of the minuend becomes larger than 10. Method B concerns borrowing a similar unit from somewhere undefined, which is then returned to the decade-digit of the subtrahend (increasing it by one). The example is explained in detail in the next paragraph.

In the upper floor, mother 7 lives with 3, her child. Accordingly, in the lower floor the mother is 4 and the child is 5. At the beginning of the story the child of the lower floor was 1 and the other child (5) refused to play with it. The excuse it used was that 1 was too small. Thus, 1 felt disappointed and played alone for many days, feeling very sad. Then, one day it grew up and became a 5. Filled with joy, it run in the building to play with the other child. The latter felt intimidated, as now 5 was larger. The solution was provided by mother 7 in the upper floor, thus demonstrating Method A of subtraction. Specifically, she decided to lend a unit to her child and so she become 6 and the child became 13. This way, the children could play together and the subtraction could be completed.

After playing that way for a long time, the upper floor mother got tired of the process and decided to stop lending the unit. In order to continue playing with the other family, she advised her child to visit the bank of decades and borrow the required unit from there. The banker decided to go through with the transaction, but urged the child to be careful and return the unit somewhere outside its apartment whenever it was to be used. Otherwise, he specifically highlighted that the number-police would arrest

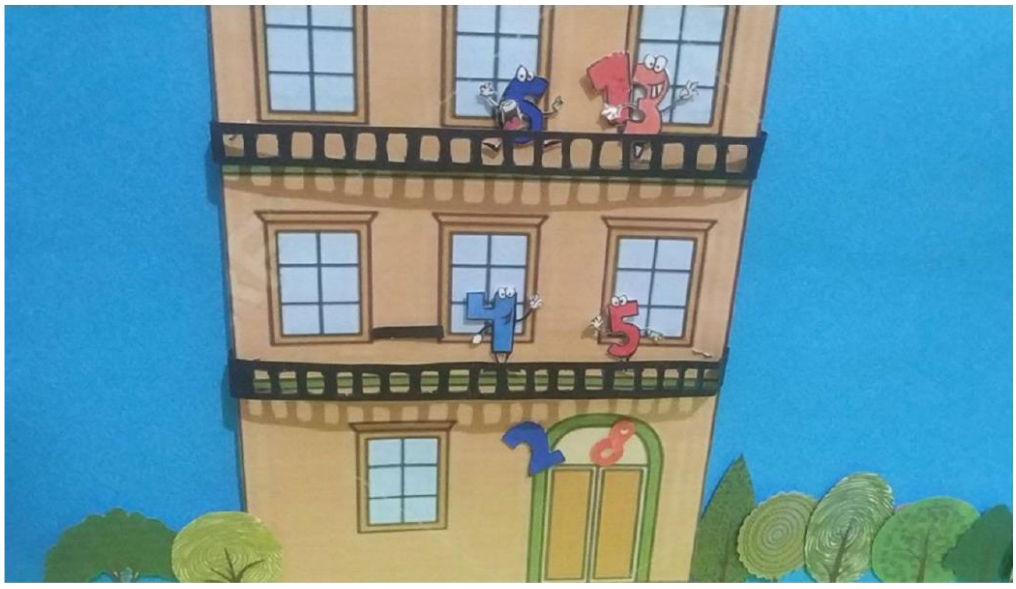

Figure 1. Playing the subtraction game, somewhere in Numberland

the upper floor mother who would face significant charges. After putting thought into the problem, the upper floor child decided that the optimal solution would be to return the unit to the lower floor mother. This corresponds to Method B of the subtraction algorithm. And thus, the two families continued their game for eternity and lived happily ever after.

The Stop Motion Animation technique was used to implement the digital story. Two-dimensional figures were constructed and placed in three-dimensional scenes. A mobile application was used to create the video (StopMotion Animation). A total of 866 photos were used and the duration of the digital story was seven minutes and thirteen seconds. It is therefore considered to fall within the scope of Digital Storytelling marginally, as the average duration of stories is approximately 5 minutes.

It is important to justify the choice of having a slightly longer digital story than expected. The first 2 minutes of the story are utilized for presenting the characters, the context and the portion of the story in which the lower level child is 1 and thus the other child does not want to play with it. This leads 1 to play alone and appear to be rather sad, until it grows into a 5. Then, the upper level child is intimidated, before the subtraction algorithms are presented. This part of the story was included in order to enhance the emotional constituent of the story, as required by the Digital Storytelling approach (Bratitsis, 2017). It provides opportunities for self-identification to the children, as many of them might have faced similar situations in real life (having others not playing with them and making fun of them or vice versa). Therefore, the digital story could easily be 2 minutes shorter, but it is very possible that its emotional impact on the children would be much lower. Furthermore, children playing with their mothers together and the danger of a mother getting into trouble because of her child's carelessness (the case of the load from the bank in the story) are also opportunities of self-identification for the children, as these are occurrences with which they can relate to, based on their experiences. Eventually, that is the essence of digital stories when designed for educational purposes (Bratitsis, 2017), as they have to convey a message/meaning to the viewers and that has to be interpretable by them, based on their experiences (following also Vygkotsky's perspective of learning).

Results

Regarding the completion rate, 66 students completed all the subtractions and 8 completed half of them or missed some. Therefore, the analysis concerned only the fully completed tests. The results are mainly cumulative and not per student.

The pre- and post-tests included 6 subtractions in which one of the algorithms described in the corresponding section of this paper was required to be applied. The results indicate that viewing the digital story had an overall positive impact on the students' performance. In the pre-test, almost half of the provided solutions, on average, were not correct. In the post-test, the average number of correct solutions rose from 3.1 to 4.9 (58% increase), as depicted in Figure 2. These observations fully comply with those in Study1 (Bratitsis & Mantellou, 2019).

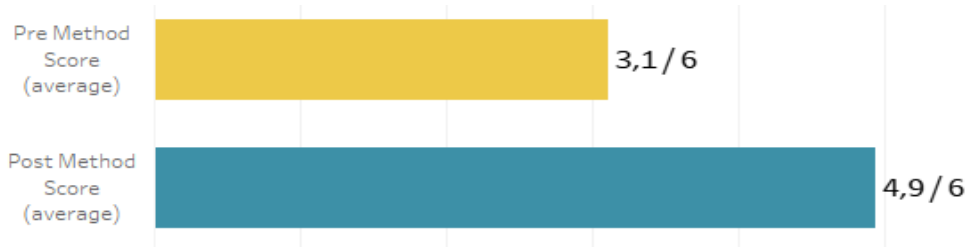

Figure 2. Mean number of correct answers for the complex subtractions (pre-test vs post-test)

Table1. Mean number of correct answers for the complex subtractions (pre-test vs post-test)

Correct answers	Pre-test	Pre-test Cumulative (%)	Post-test	Post-test Cumulative (%)
6	13	20%	31	47%
5	11	36%	22	80%
4	5	44%	5	88%
3	9	58%	2	91%
2	7	68%	1	92%
1	11	85%	2	95%
0	10	100%	3	100%

Examining the calculations of the students more closely, in the pre-test more than 40% of the students solved less than half of the subtractions correctly. In the post-test the corresponding result was less than 10%. Likewise, only 20% of them solved all 6 subtractions correctly in the pre-test, whereas about half of them (47%) achieved the same score in the post-test. Furthermore, in the post-test 80% of the students made only one or no mistakes at all. The corresponding percentage in the pre-test was 36%, further highlighting the performance difference between tests. Table 1 presents these results with cumulative percentages and Figure 3 compares the performance between the pre- and the post-test.

As can be seen in Figure 3 and Figure 4, students significantly outperformed themselves after viewing the digital story. In fact, the difference depicted in the right end of Figure 4 is impressive, indicating the difference in providing 6/6 or 5/6 correct solutions respectively.

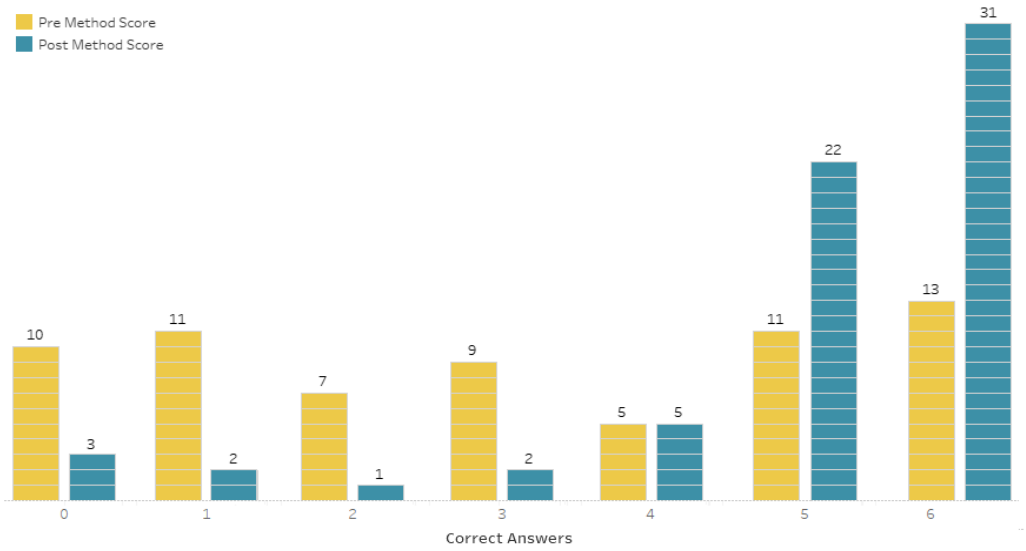

Figure 3. Pre-test (yellow) and post-test (blue) correct answers' distribution

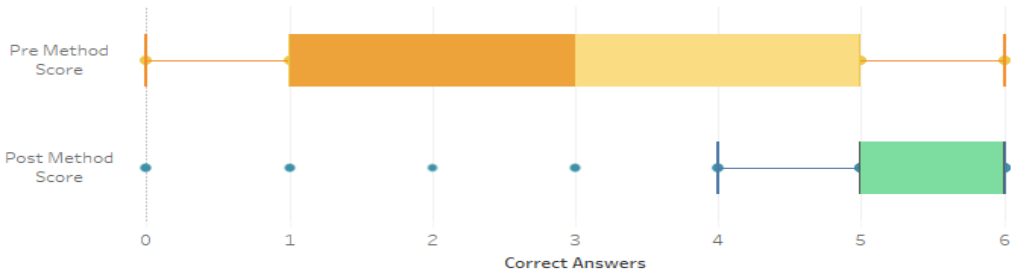

Figure 4. Pre-test (orange) and post-test (green) correct answers boxplots

Figure 5. Individual comparison: pre-test and post-test joint distribution (subtraction with borrowing)

The boxplot in Figure 4 leads to an interesting observation. In the pre-test, about half of the students had 3 correct solutions (pre-test median = 3). In the post-test, the median is 5, indicating that half of the students provided at least 5 correct solutions.

Examining the individual performance of the students in both tests, more interesting observations can be made. Figure 5 presents the number of students who obtained a certain pair of scores in the pre-test (horizontal axis) and the post-test (vertical axis). For example, the number of students who provided 5 correct solutions in the pre-test (5 on the horizontal axis) and shifted up to 6 correct answers in the post-test (6 on the vertical axis) is 3 (the number appearing in a circle, in the corresponding cell of the diagram). Furthermore, Figure 5 indicates that 43 students (65%) improved their performance in the post-test (green circles), while 12 students (18%) had lower performance in post-test (red circles).

As aforementioned, 8 of the students did not solve all the provided exercises in both the tests. These were children that had already been diagnosed with ADHD. It is to be noted that the classes at this age are nowadays often inclusive ones, as were those of the study. In the pre-test they calculated one or two subtractions each, whereas in the post-test they completed at least 5 (some of them even all 6) subtractions. Although their performance was not included in the cumulative numbers discussed earlier in this section, still this observation seems significant. It is common for children with ADHD to not participate in all classroom activities and thus not fulfill all the teacher's requirements, based also on the severity of their condition. They are usually appointed an additional teacher who provides individual support to them and often works at a different task than that of the whole class. In this case, the fact that they shifted from the one end of the effort put in the activity (1-2 exercises) to the other end (5-6 exercises) is noteworthy. Also, the number of children was low, but still a significant portion in total (8/74 – 10.8%). It seems that the engagement with the digital story motivated these children to fulfill their "obligations", although this conclusion cannot be decisively formulated. Thus, this provides grounds for further research with the utilization of Digital Storytelling for teaching children with learning deficiencies, adding up to existing research (Bratitsis & Ziannas, 2015; Bratitsis, 2016).

Figure 6. Mean value of correct answers to simple subtractions (pre-test vs post-test)

The two distributed worksheets also included 4 simple subtractions which did not require an algorithm with the need to borrow a unit. Although the digital story was designed to address the mistakes observed when applying one of the two aforementioned algorithms, the simple subtractions were also analysed. Specifically, in the pre-test the mean value of correct solutions was 3.3/4 (82.5%) subtractions for the 66 students. In the post-test it was 90% (3.6/4). Figure 6 depicts this difference.

Examining the calculations of the students more closely, as in the case of the complex subtractions, Table 2 shows that 38/66 (58%) students solved 4/4 subtractions in the pre-test. The number increased to 79% (52/66) in the post-test. Similarly, 24% of the students made one mistake in the pre-test, as opposed to 12% in the post-test. These differences are further highlighted in Figure 7 which shows how the students improved their performance after viewing the digital story, following a similar presentation format as in the case of complex subtractions.

Table 2. Correct answer distribution between pre-test and post-test (simple subtractions)

Correct answers	Pre-test	Pre-test Cumulative (%)	Post-test	Post-test Cumulative (%)
4	38	58%	52	79%
3	16	82%	8	91%
2	7	92%	3	95%
1	2	95%	1	97%
0	3	100%	2	100%

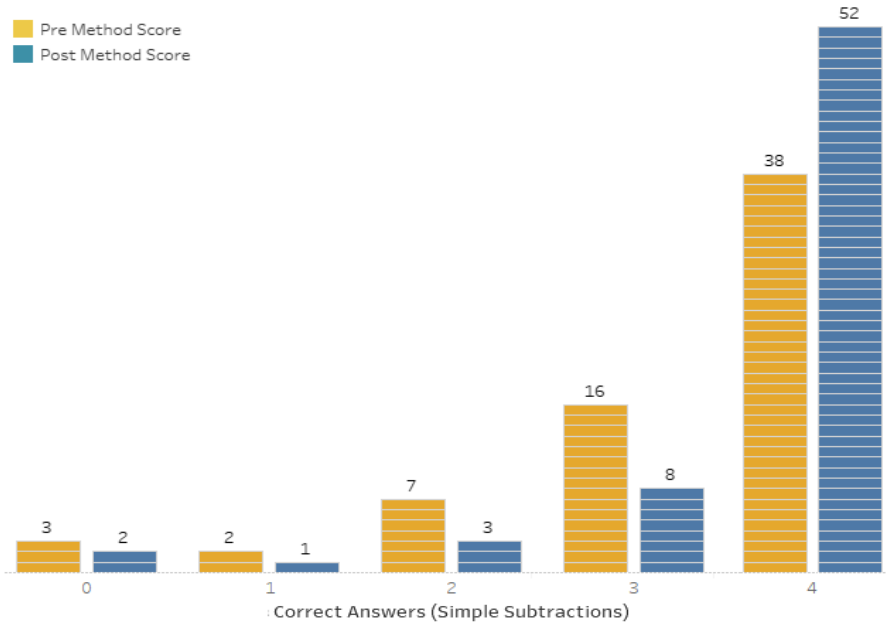

Figure 7. Pre-test (yellow) and post-test (blue) correct answers' distribution (simple subtraction)

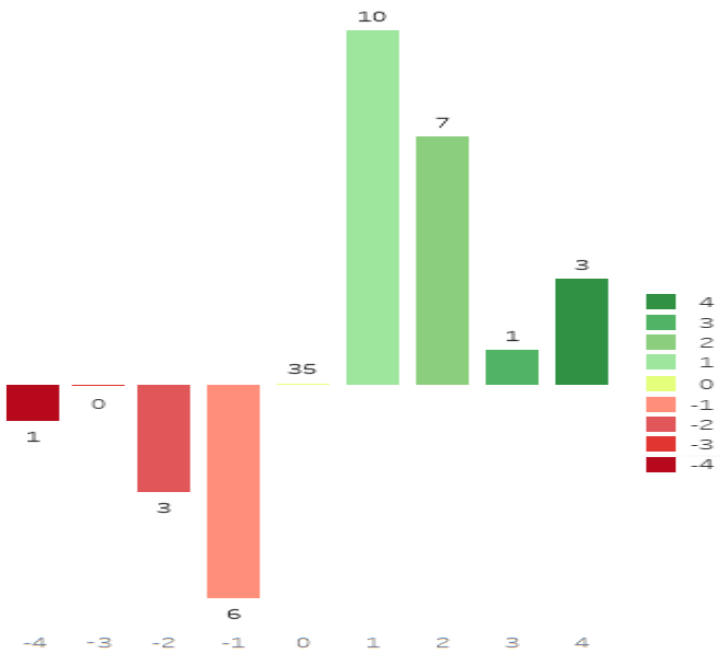

Figure 8. Correct answers' alteration pre-test vs post-test (simple subtraction)

In the case of simple subtractions, a positive impact of the digital story was also observed, although at a smaller scale. Figure 8 shows that 21 students (32%) improved their score in the post-test. Also, 35 students (53%) had the exact same number of correct answers in both tests, while a smaller percentage (15% - 10 students) provided a lower number of correct calculations in the post-test.

Overall, the results are in line with those from Study1 in which a common mistake in the complex subtractions was that the students solved them as if they were simple ones. In the case of the control group in Study1, those mistakes were significantly higher, in both the pre- and the post- test (Bratitsis & Mantellou, 2019). Attempting to interpret this observation, one can assume that the engagement with the story led the students to be more careful when solving subtractions, despite of them being complex or simple ones. It is important to mention that in both studies, some of the students said while completing their post-test that "they had to be careful so that the upper level mother wouldn't be arrested".

Overall, the data analysis in this paper points to the direction of further validating the findings of Study1. Indeed, it seems that the design of a digital story in order to utilize it for teaching mathematics in Primary School was successful and very promising. Focusing on the subtraction algorithm, the approach described in this paper seems to address problems that arise while teaching it, as they are recorded in the literature. The connection of the students with the feelings of the characters appearing in the story seem to have provided additional motivation to the students in order to perform the correct calculations. Although it cannot be proved that they deeply understood the subtraction algorithms, on a conceptual level they utilized their sympathy for and connection with the upper floor mother (and child at extend) in order to build their own strategy for applying the algorithm. Furthermore, although also not studied in detail, it seems that the students intuitively followed Method B of the subtraction algorithm, that of returning the borrowed unit to the subtrahend's decade digit (impersonated by the lower floor mother in the digital story). Overall, there was a multilevel emotional attachment, resulting from self-identification (Bratitsis & Mantellou, 2019). This could be considered as positively affecting the students' attitude towards mathematics overall, as through stories abstract concepts become concrete or even tangible. Of course further studies are required towards this direction.

Discussion

In this paper, the aim was to further validate and verify the results of a previous, smaller-scale study (Bratitsis & Mantellou, 2019). The focus was on utilizing Digital Storytelling for teaching mathematics in Primary School. In particular, a digital story was designed and created that presents the two basic variations of the subtraction algorithm with borrowing. This is an issue that, as mentioned above, makes it quite difficult for 2nd Grade students and this also contributes to the cultivation of a negative attitude towards mathematics. The vertical subtraction algorithm with borrowing is performed incorrectly by many students, which was evident in this study as well.

On the other hand, an important goal of mathematics teaching seems to be to address mathphobia through modern curricula. Given the use of narrative approaches to meaning-provision on abstract concepts and the intense emotional involvement of students, a digital story was used in the present study to determine if this problem can be addressed. It is important to highlight the applied teaching approach which merely involved just viewing and re-narrating the digital story. No other intervention, exercises or teaching tasks were carried out, and the classrooms in which the study was conducted had already been taught the designated algorithms.

The results confirm the difficulty that children face in this matter, as indicated by the amount of mistakes in the pre-tests. On the other hand, the improvement of the vast majority of the children in the post-test shows that they were positively affected by the digital story. Their attitude as a whole showed that this approach was pleasant for them and strengthened their active participation and involvement. They asked whether there were other stories about mathematics, which is a strong indication of how Digital Storytelling can be used to tackle mathphobia. Of course this is in line with the ongoing research over the last decade on the utilization of storytelling in general (not necessarily in a digital form), as discussed in the corresponding section of the theoretical background. In addition, there was a strong emotional involvement of the children with the characters of the story, whose actions they recalled to explain the solutions they proposed in the post-test exercises.

Overall, this paper provides important indications of how positive the utilization of Digital Storytelling can be for teaching mathematical concepts. Of course, this is a small case study and the results cannot be generalized beyond doubt. However, if one considers the number of papers that have appeared in recent years in the literature that highlight the positive benefits of Digital Storytelling utilization, one can conclude that the observed results are not just coincidental. As explained by researchers who work with Digital Storytelling, the compelling power of stories can often be enough. Besides, Ben Haggarty, a famous performance storytellers once stated in an interview: “It’s the power of those things. They can take you over, being lost in a story. You can take people anywhere, whether they want it or not”. This seems to be verified in this study, as the power of the story was enough to engage the students and help them apply the algorithm correctly, as opposed to what usually happens, leading them to many mistakes in that process. Stories, especially in a digital form are not to be considered as plain teaching material. They go far beyond presenting concepts in a multimedia format; but one has to fully understand the power and the fundamentals of storytelling in order to fully embrace the dynamics of this promising field.

Future plans include further verification of these findings, but also the design of more digital stories for other abstract concepts (also of other disciplinary areas) in order to provide empirical evidence about the efficiency of Digital Storytelling in Education.

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