Understanding attitudes towards mathematics and perceived difficulty of word problems for grade-2 students completing a summer activity

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Abstract: This contribution addresses the issue of summer learning loss in mathematics and possible ways to mitigate it. In summer, the students (and their families) are left alone in dealing with mathematical exercises and problems. One of the assumptions that grounds the project is that mathematical storytelling can improve students' attitudes and positive dispositions towards mathematical word problems. We analyse the attitudes, the perceived difficulty and the values that emerge in grade-2 students solving mathematics problems on a web-app during the summer break. The students' answers have been collected via audio recordings, and they have been analysed once transcribed. The findings reveal that those who have more positive attitudes, and in particular declare to have liked the activity the most, also give more elaborate answers to the tasks, and these findings confirm the crucial role of attitudes in mathematics problem solving processes.

Keywords: attitudes, perceived difficulty, summer break, storytelling, web-app.

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1 Introduction and theoretical framework

This contribution addresses the phenomenon of summer learning loss in mathematics for primary school students. Summer learning loss in mathematics is the decline in mathematics knowledge, skills, and procedural fluency that occurs during summer break due to a lack of academic engagement, often resulting in a loss of roughly 2.6 months of grade-level equivalency. It represents a 25%–34% drop in school-year gains, impacting computational skills more severely than reading. One of the key aspects of summer mathematics learning loss is that students score lower on standardized math tests at the end of the summer than at the beginning. The lack of regular, structured practice with math concepts over the long break has been identified as the main cause of loss, and one main consequence is that teachers often spend weeks at the beginning of the school year re-teaching, leading to widened achievement gaps. Research has shown evidence that learning

loss is particularly critical in socially disadvantaged contexts, contributing to exacerbate inequalities (Lynch & Mancenido, 2023). Calder and Campbell (2016) consider educational underachievement of indigenous students. According to INVALSI (2021), the learning loss in mathematics does not concern basic knowledge, which is relatively easy to recover, but rather reasoning skills, logical-mathematical argumentation, and problem-solving abilities.

A possible way to mitigate the summer learning loss has been identified in the use of web-apps that prompt students to engage with mathematical activities, as apps have the potential to lead the students to explore new ideas in mathematics when they solve problems (Calder & Campbell, 2016), and to develop positive attitudes. In this respect, Calder and Campbell (2016) maintain that the use of apps changes the ways students engage with mathematics, facilitating understanding.

Our research is situated within this line of inquiry, focusing on how the use of web apps impacts students' attitudes and on other affect-related aspects that emerge when students engage with a web app. According to Leder and Grootenboer (2005), attitudes change when individuals go through highly influential events or circumstances. Deci and Ryan (2000) have shown positive correlations between positive attitudes and enhanced learning outcomes, as well as between sense of autonomy and performance in mathematics. Not only attitudes, indeed: values also have an important role in individuals' commitment to and maintenance of the actions they choose in their learning journeys (Seah & Andersson, 2015). For example, in the OECD's Learning Compass 2030 conceptual framework for future education, values are placed at the center of the learning experience (OECD, 2019). Thus, the theoretical framework of our research pivots around attitudes, perceived difficulties, values and storytelling, as we succinctly recall in the next paragraphs.

Di Martino and Zan (2010, 2011) propose a definition of attitudes that is grounded on students' accounts of how they lived mathematical activities they had been exposed to during the school years. From the data, the researchers infer a three-dimensional model for attitudes towards mathematics that is made of (i) students' emotional dispositions as they express liking or disliking the subject, (ii) their perceived competence and (iii) their visions of mathematics. Di Martino and Zan (2010, 2011) build the definition of perceived competence on Bandura's (1977) definition of self-efficacy. Bandura (1977) argues that a student's self-efficacy is a major factor in whether he/she will attempt a given task, how much effort he/she will put on it, and how resilient he/she will be when difficulties arise.

During the task-solving process, a student may encounter multiple difficulties that can depend on both the student's individual characteristics (such as abilities, knowledge, beliefs, and attitudes) and the specific characteristics of the task (such as the text or the mathematical content involved). These aspects can influence the student's perception of the task and, consequently, its perceived difficulty (Spagnolo & Andrà, 2025). Thus, while closely connected, difficulty and perceived difficulty are two different aspects (Spagnolo & Saccoletto, 2023). The issue of subjective difficulty has been explored over the past 30 years under various terms (e.g., Eccles & Wigfield, 2020; Doz et al., 2023). Doz et al. (2023) suggest that the nature of the "feeling of task difficulty" is metacognitive, stemming from the monitoring of ongoing task processing, and awareness of this process influences self-regulation, effort, emotions, and strategy use.

Values are deep personal truths or commitments cherished by individuals, they help motivate long-term choices and shorter-term priorities and they are highly structured, forming value systems (DeBellis & Goldin, 2006). Values are qualities that are considered important to us, thus a motivating force that prompts us to get what we want, and that are socially mediated. Values have an ethical and moral connotation (Seah, 2019). Values are also distinguished from beliefs, as the latter are what that an individual considers as true, while the former reflect what is considered as important (Seah, 2019). Mathematics is all but an entirely value-free (or culture-free) product (Bishop, 1988). Seah (2005) underlines that mathematics is a discipline shaped by the collective knowledge of different cultures, hence the mathematics taught and learned in schools is inevitably open to cultural interactions, and thus values shape the mathematical experiences in the cultures within which students are immersed. There exist various classifications of values. Lim and Ernest (1997) categorized values into three different categories: epistemological, social, cultural, and personal values. Epistemological values are related to the theoretical aspects of mathematics teaching and learning, while social and cultural values refer to human responsibilities related to mathematics education for society. Personal values are values that affect the individual or learner. Bishop (1988) categorized the values taught in mathematics classrooms into three categories: mathematical values (for example, "rationalism", or "openness"), mathematics educational (for example, being efficient in selecting a strategy), and general educational values (such as "honesty", or "good behavior").

Finally, in dealing with a word problem, which entails some extent of storytelling, the students are supposed to base their solving process upon a representation of the problem, which is grounded in its narrative. Zan (2011) suggests the context of the story being rich and meaningful for the students and the questions following in a narrative way from the context and not being artificial questions about it. These considerations are inspired by Bruner's (1986) distinction between a narrative thought and a logical thought, or cognitive functioning that provide two distinct ways of making sense of reality. While logical thought forms categories and relates to one another, the narrative one creates stories, grips drama, makes historical accounts believable and locates experiences in space and time (Zan, 2011). In the word problem, indeed, there is information relevant to its representation, as well as there is information relevant to its solution and "the point is that the data a child needs to represent the problem are not necessarily those he/she needs to use in the solution" (Zan, 2011, p.6). Furthermore, we argue that emotional dispositions, perceived competence, difficulty of the task and values are tickled within the narrative structure of the mathematical problem, and they intertwine with the solution phase.

The Italian MATES project aims at examining the potential of the web-app when the teacher is not (and cannot be) present with the students, and especially in examining: (i) the role of attitudes as they have been put forward by Di Martino and Zan (2011) in shaping the experience with the app, (ii) the perceived difficulty of the tasks (see Spagnolo & Andrà, 2025), and (iii) the values that emerge when students explore powerful mathematical ideas. The tasks the students are dealing with are word problems that are designed following Zan's (2011) findings about storytelling in mathematics. The research questions we aim to answer is: What attitudes towards the mathematical word problems proposed by the web-app emerge among grade-2 students? How difficult are the tasks perceived? Is there any relationship between the attitudes, the perceived difficulty and the values that the students elicit when a word problem characterized by a rich context is proposed to the students?

2 Methods

In order to attempt to answer the research questions, we involved a sample of 125 children having completed the grade-2 school year to participate in the activity of completing six tasks presented through a web-app during the summer of 2024. The students' recruitment followed a stratified random selection: schools in the

municipalities of Milan and Naples were randomly selected to take part in the study. Within each selected school, the teachers who were teaching in grade-2 classes adhered to the project voluntarily. They received a series of three webinars from the researchers of the project about the app, its potential and its use. Then, the teachers told the families (parents in most cases) how to open and use the app. With respect to the demographic variables of the participating students, the random selection assured a fair distribution with respect to gender and socio-economical statuses.

In this paper, we consider the sixth task, which builds upon the tale of "the man who counts" (Tahan, 2019). We firstly report a summary of the story in what follows (to note, the first person narrating the story is a character named Ali).

> Beremiz and I were approaching the ruins of a small village close to Baghdad, when we saw a poor man in pitiful condition. He was Salem Nasair, a rich merchant in Baghdad. Unfortunately, his caravan had been attacked and robbed. Salem was starving, so he asked for something to eat. I replied that I had three loaves of bread, while Beremiz, the Man Who Counts, had five loaves of bread. Salem begged to share our loaves with him, so that he would give us eight gold coins as soon as we reached Baghdad with him. Since we had 8 days of journey, we agreed to consume only one loaf of bread a day, dividing it in three equal parts. Once we entered Baghdad, a powerful vizier crossed our way and suddenly recognized the rich merchant, who told him the story. The vizier borrowed the eight gold coins to Salem to compensate us for our generosity. Turning to the Man Who Counts, Salem said: "Here are five gold coins for your five loaves." Then to me: "And three to you for your three loaves". Nevertheless, Beremiz, the Man Who Counts, raised an objection: "this subdivision, which may seem simple, is not mathematically correct. Since I gave five loaves of bread, I must receive seven coins. My friend who gave three loaves of bread should only receive one." But, the vizier and Salem asked for clarification.

The story stops and the participants are invited to figure out why Beremiz made such a proposal. Then, the story ends with this short part:

> "But this division," added Beremiz, "is not perfect in the eyes of the Almighty. Since everyone has made available what they had, we divide the reward in half: 4 coins for each."

After having read, or listened to (the web-app offers both possibilities) the story, the children are invited to draw it, to make sense of the 7-1 division and to say which one among the 5-3, the 7-1 and the 4-4 division of coins they prefer, and why. They have also to rate, from 1 to 3, how much they liked the task and how much they think they have done it well, and these are taken as indicators for attitudes; then they have to rate, from 1 to 3, how easy they found it, and this is a proxy for perceived difficulty.

Given the very young age of the children, we operationalised a necessary simplification of the theoretical constructs of emotional disposition and perceived difficulty as put forward by Di Martino and Zan (2011), and of perceived difficulty (Saccoletto e Spagnolo, 2023). The rates have been represented with "stars": each student could choose among one, two or three stars to express how much they liked the activity, how much they think to have done it well and how clear they found it. The representation with stars is well known and widely used within the Italian school system as a way of rating and we did not consider any validation for this rating scale, because of its extreme simplicity. After having selected the number of stars, the students should also leave an audio message to comment on their choices. Values emerge in the children's accounts for why they preferred a certain choice over the others. We considered both mathematical and non-mathematical values (Andrà et al., 2025).

The data have been collected through the app, as the participants select the number of stars (from 1 to 3) in giving their ratings, and register an audio message with their answers. They also uploaded drawings. In the data analysis, we considered the frequencies of low, intermediate and high appreciation of the task, self-confidence and perceived difficulty, and we analysed the audio recordings and the drawings with a qualitative lens on values.

3 Data analysis, interpretation and discussion

We firstly analyse the quantitative data, then we examine the students' accounts, from which values emerge.

3.1 An eye on the quantitative data: considering the entire sample

Figure 1 shows the distribution of the answers to the questions: (i) did you like the task? (with 1 = a little, 2 = intermediate, 3 = a lot), (ii) do you think you did it well? (with 1 = not so much, 2 = intermediate, 3 = yes), (iii) did you find the task clear? (with 1 = not so much, 2 = intermediate, 3 = yes).

We can notice that the majority of the students liked the task very much (60%), they thought they had done it very well (66%) and they perceived the task as clear (57%). About 20% of the students opted for an intermediate level and the remaining part selected the option "a little".

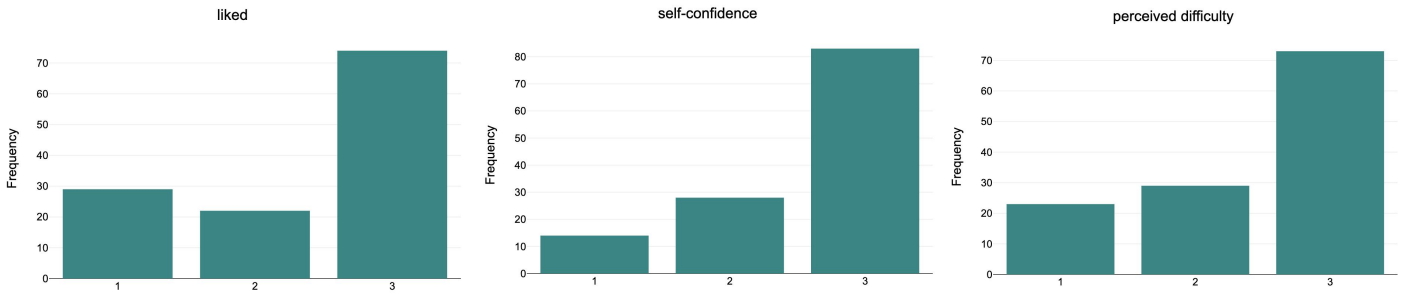


Figure 1. Distribution of the answers to the questions about attitudes and perceived difficulty.

Note. Figure 1 to the left shows the answers to the question “did you like the task?” and about 30 students replied “no”, while about 20 students opted for an intermediate level, and the majority of the students (76, which correspond to 60% of the sample) said “yes”. Figure 1 in the middle shows the answers to the question “do you think you did it well?”, with about 15 students replying “no”, about 25 opting for an intermediate answer, and more than the half of the sample saying “yes”. Figure 1 to the right shows the answers to the question “did you find the task clear?”, with about 20 and 30 students finding it not clear, or so and so, respectively, and 59% of them (74 students) finding it clear.

If we look at the Sankey diagram in Figure 2, we also notice that all the students who replied “a little” to the question “Do you think you did it well?”, which is an indicator of low self-confidence, also liked the task “a little” (indicator of negative emotional disposition, or dislike) and found the task not clear, a sign of high perceived difficulty. Some of the students who disliked the task, conversely, thought to have done it right, and the same holds for some of those who found it difficult. Among those who opted for “a lot” in response to one question, many also opted for the same option in answering the other two questions, and a similar situation can be noticed for those students who opted for an intermediate case. All in all, we can say that there is an overall consistency between liking the task, thinking of having done it well and having found it easy.

These results help us answer the first two research questions, which are: Which attitudes towards the mathematical word problems proposed by the web-app emerge? How difficult are the tasks perceived? In fact, from the quantitative data, we can see that a mildly or strongly positive attitude features the majority of the students when dealing with the task, and the task has been felt as easy or mid-easy by the majority of the students. A very few students think they performed badly, while some more of them did not like it, or found it difficult. With respect to the challenge of engaging students during the summer break, we can say that also those who did not like the task were engaged, as they completed the activity. However, it makes sense to dwell on the qualitative responses that the students gave in

commenting on the task, in order to see if we can distinguish between those who liked and those who disliked the task.

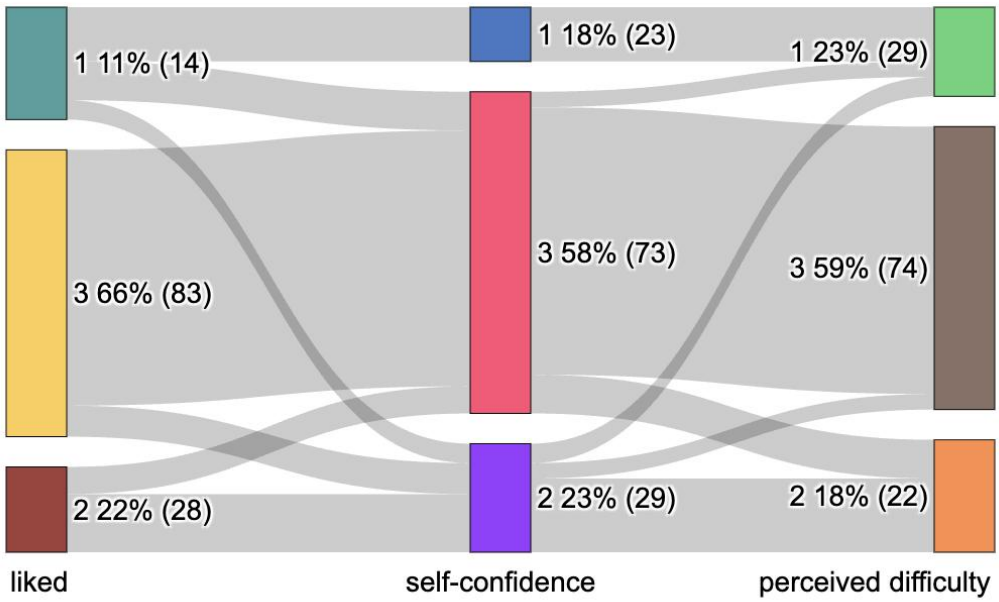


Figure 2. Sankey diagram of the distribution of the answers to the questions about attitudes and perceived difficulty.

Note. A Sankey diagram is a type of flow diagram used to visually represent the flow of values between different entities.

3.2 Digging deeper with qualitative data: excerpts from drawings and audio recordings

It emerges from the quantitative analysis that many children liked the activity. Specifically, 76 children gave the maximum score (3=a lot). A good percentage of them also believe to have done it well. If we look at the 76 children who gave 3 (the maximum score) to "like", we see that 70 of them (92%) provide detailed and reasoned answers to the open questions, which asked about the model they preferred between 3-5, 1-7 and 4-4.
Of the 30 children who gave 1 to "did you like it?", 13 (43%) do not answer, and among the other 17 ones who gave slightly detailed answers, there are 7 who do not actually justify their choice (for example "I excluded the other two ones because for me this is the best solution", or "I say 4 and 4, because I give 4 coins to my friend and I keep 4 coins for myself": these answers are not justifications for the choice

made). Thence, among those who selected 1 to the “I like” question, we only have seven answers out of 30 in which there are justifications, and they are:

Alice:	My solution seems fair as… it seems fair as a division, because both of them gave something, so eh… so both of them must receive the same… the same amount of coins. I haven't found any other divisions that could be done and these are fine with me.
Barbara:	I chose this solution because they helped each other, giving up everything they had.
Carlo:	I excluded 7-1 and 5-3, because 5-3 didn't seem very fair to me, instead 7-1 is because it could work, but they were both kind, so I wanted to do it in equal parts.
Davide:	I chose the equal division 4-4, because in my opinion it is the most beautiful. I would eventually choose the 5-3 one, which rewards each person for the loaves they put in.
Elisa:	I excluded the other two because… um… the first one because the one I chose is not based on mathematics, but on friendship. And no, I don't have another different one of… of… operation.
Fabio:	In my opinion, the most correct answer is 7-1, because mathematically it is more correct.
Giacomo:	I excluded the other two ones, because they were not in equal parts and there was a risk that they would argue.

In the Italian language, the adjective “giusto”, which has been translated as “fair”, “right” or “equal” in English, has two connotations: one is about being right mathematically speaking, and the other one is about being fair on an ethical level. The children use the adjective “giusto” and from the context we can infer that they mean “fair” or equal. With an eye on values, we can observe that it is not the mathematical value of rigor and correctness that emerges from the children’s words, but rather the moral value of equity: the idea that both Beremiz and Ali gave something (Alice), that they gave everything they had (Barbara), that they were kind (Carlo), and that the division 4-4 is the most beautiful (Davide). Giacomo wants to avoid the risk that they would argue. And Elisa elaborates that the 4-4 solution is the one based on friendship, deliberately contrasting it with the one based on mathematics. Beyond the specific context of this story and of this activity, we see the importance of dwelling on the various nuances of the meanings that a value (equity, in our case) can have for different students, and the richness of such a variety. One of the key features of the interpretative lens we are using resides in its ability to capture such nuances and to consider each student’s contribution as unique and worthy of attention, instead of forcing them to belong to some overarching category.

As we said before, the answers of the children who selected 3 to the question about how much they liked the activity are more elaborate, and there are many more. A number of them elaborate on the fairness of the division, like

Anna:	I chose 4-4 because they both sacrificed themselves so I would like to pay them equally.
Bruno:	I too, with a friend of mine, would divide it equally.
Cinzia:	I chose 4-4 because there are 2 friends and in this way each one had 4 coins. I excluded 7-1 because I didn't understand it; I excluded 5-3 because otherwise one had more money and the other didn't.
Daniele:	I don't want them to fight so I'd give 4 coins to each one of them.
Elena:	I chose 4-4 because I didn't want more or less and so I chose an even division.
Franco:	I thought 4-4 because I was taught to always divide things equally.
Giorgia:	For me it's right to do 4 and 4 so both are happy.
Ilaria:	Dividing equally is the right thing to do, because it doesn't matter who puts in more or who puts in less. It's the same thing my friend and I would do, because she will bring 8 and I will bring 2 and together... is 10.
Laura:	I excluded the other two ones, because I wanted Beremiz and Ali to have the same amount and not have anymore arguments and I wouldn't have chosen another one.
Marco:	I liked the one where they divided the coins 4 and 4, because they helped both of them, not just one, not just Beremiz, not just Ali, but they helped together.
Nora:	They can't be one more and one less, so I like 4-4, the coins are equal, so the one who has fewer coins, that is because both have done good deeds and not one more and one less, because both have done a good deed.
Olivia:	I'm also generous and I like to divide equally.

In Elena's protocol, we notice that the adjective "even" is used in the everyday sense of "fair" and not in the mathematical sense, pointing to the difference in meaning in everyday language and in mathematical language. Also in Franco's protocol, he uses the verb "to divide", which in the everyday sense is "to divide into equal parts", thus referring to his knowledge of the world (Zan, 2011). A similar comment can be done for Ilaria's protocol. We notice, overall, that the majority liked the 4-4 division. Other students, who opted for 3 in the scale of "I like", offer different points of view:

Paolo:	Well, I prefer 4-4 but the right one is 1 because it's more mathematical
Roberta:	I thought the division should be 5-3, because each loaf is worth 1 coin.
Samuele:	I would have divided 7 and 1, because Beremitz divided more loaves.
Tania:	I excluded 7 and 1, because there is too much difference; I excluded 4 and 4, because Beremiz gave 2 more loaves than Ali, it seems fairer to give 5 and 3.

In Samuele's protocol, we notice the use of the verb "to divide" in a non-rigorously mathematical sense, but in a rather approximate sense, like: if more

loaves, then more coins. Beyond the specific context of the story, we can notice that a methodology of this sort allows us to capture the processes through which the students made sense of the task and reach a solution that seemed appropriate to them.

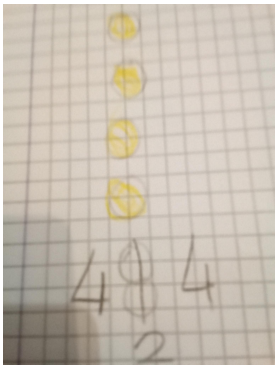
It is often possible to observe a correspondence between children's verbal arguments and their drawings. Among children who opt for 4-4, it is possible to identify specific categories of drawings that align with corresponding categories of responses, and some examples are shown in Figure 3.

The selection of the 4-4 option by some children reflects an underlying emphasis on interpersonal relationships and the importance they attribute to friendship (Figure 3a, as well as Elisa's, Bruno's, Cinzia's, Ilaria's and Olivia's words). Children's preference for the 4-4 option is often motivated by a sense of fairness and the perception of equal distribution (Figure 3b and Alice's, Barbara's, Carlo's, Davide's, Anna's, Elena's and Nora's words). Some other children opt for a 4-4 division to avoid upsetting either party (Figure 3c and Giacomo's, Daniele's and Laura's words).

Reading the protocols, we also notice that some children, while recognizing the correctness of the 7-1 solution, choose the 4-4 distribution because both parties contributed to the best of their means. Also the drawing in Figure 4 shows that the student has understood the mathematical sense of the story: Ali ate 8 over 9 pieces of bread (colored in yellow) and left one to S. Beremiz ate 8 over 15 pieces of bread (orange) and left 7 to S. Carlo, in his words, recognises that 7-1 "could work", but his acknowledgement that "they were both kind" leads him to opt for the 4-4 division.

Figure 3. Some children's drawings that support the preference for the 4-4 division.

(a)



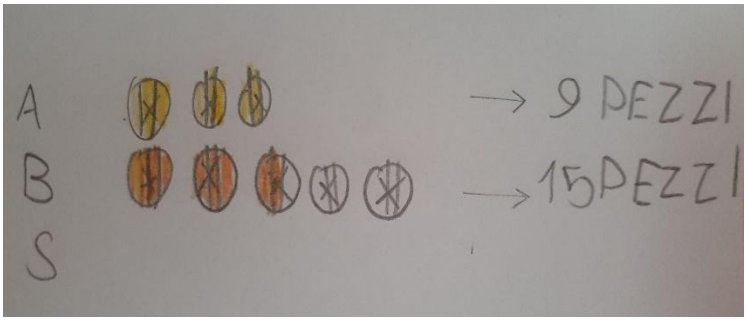
(b)

(c)

Note. Figure 3a represents Beremiz and Ali with four coins each. Figure 3b represents 4 coins colored in yellow, and on the bottom there is a number 8, strikedthrough, and number 2 is below it (meaning "divided

in 2”) and two numbers 4 are written to the right and to the left of the crossed out number 8. Figure 3c represents, from left to right, the vizier, Salem, 8 coins with Ali and Beremiz who take 4 of them each.

Figure 4. One of the drawings from which we can infer that the students have understood the sense of the 7-1 division.



Note. The letters A, B and S to the left of Figure 4 stand for Ali, Beremiz and Salem respectively. Beside A, three leaves of bread are drawn, divided into 3 parts and eight of them are colored in yellow. An arrow points right and "9 pezzi" ("9 pieces") is written. Beside B, five leaves of bread are drawn, divided into 3 parts and eight of them are colored in orange. An arrow points right and "15 pezzi" ("15 pieces") is written.

With respect to Zan's (2011) distinction between narrative and mathematical thoughts, we can notice that the drawings in Figures 3a and 3c contain some narrative elements, as they represent the characters of the story, but the same drawings also contain mathematical elements, namely the four coins that result from the division. The drawings in Figures 3b and 4 represent only mathematical elements.

4 Conclusion

The results of our study show that the activity with the app, grounded in storytelling, generally supported positive attitudes towards mathematics, as many participants liked it and/or felt they had done well. According to existing literature, this enhances learning and in fact many students who liked the task also gave detailed and thoughtful answers about why they preferred a model over the other two ones. At the same time, the students, who liked the activity less, gave less accounts for why they made their choices, confirming a strong relation between attitude and giving sense to the activity.

Values emerge in the participants' accounts: friendship, equity, the importance of giving anything one can give, avoiding discussions. They are not mathematical values, but rather social values that make sense to the students and are central for their lives. According to Bishop's (1988) values categorization, the engagement of students in the web-app activities enables the emergence of both their own general educational values (i.e. equity, friendship, peace) and mathematical values (i.e. the possibility of having multiple solutions to a given problem). The students had the

opportunity to compare the different solutions presented by the protagonists of the story, understand the assumptions (not necessarily mathematical or mathematically correct) on which they were based, and choose their preferred solution based on their own values. The engagement of students in this process, which is pivotal to promote key competences such as critical thinking and decision making, constitutes in our opinion the very success of the activity. It is worthy to note that storytelling played a key role as it achieved the goal of connecting a mathematical word problem to the lives of the children, allowing the representation of the problem to support their solution process.

With respect to the difficulty of the task, a small percentage of them found it difficult, while the majority found it easy. Notably, also those who found it not easy, completed it and in some cases gave detailed accounts: one example is Cinzia, who declares to have not understood why 7-1 should be valid, but anyways had gone on and ended the task with her solution.

The study presented, although very promising, has some limitations that are inherent to the context in which the planned activities take place and are therefore largely beyond control. Indeed, the use of the web app is subject to two constraints: a) it is scheduled for the summer period; b) it requires the involvement of a responsible adult. These two factors introduce variables that are neither predictable nor controllable. On the one hand, using the web app during vacations requires adequate internet connectivity, which is often not guaranteed in holiday locations. On the other hand, the responsible adult may lack the digital literacy necessary to interact effectively with the web-app. The second constraint could be partially mitigated through preparatory meetings aimed at the adults, which would serve, on the one hand, to engage them in understanding the importance of the activities and their supportive role, and on the other, to anticipate the technical difficulties they might encounter. However, the size and random geographical distribution of the sample examined lead us to hypothesize a generalizability of the findings obtained.

Acknowledgements

We thank the students, their parents and the teachers involved in the project for the data made available. This research has been funded by the Unione Europea, Next Generation EU, Missione 4 Componente 1 CUP D53D23013070006, PRIN2022 “Coming to terms not only with the pandemic. Mathematics learning loss in primary school: underlying factors and interventions”, Prot. 2022TWCJAS.

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