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Engagement in mathematics through digital interactive storytelling

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This paper presents the preliminary results of an experimental work conducted on the digital storytelling in Mathematics, as part of the project Prin 2015 “Digital Interactive Storytelling in Mathematics: a competence-based social approach”. In particular, it examines how the immersive aspect of a storytelling can influence students’ engagement and attitude to learning Mathematics by comparing their usual attitude in the classroom. Early findings show that the immersive aspect of the storytelling, together with collaborative work and online interaction, may lead to a change in students’ attitudes towards mathematics.

Keywords: Attitude change, storytelling, role taking

Introduction

This paper presents the preliminary results of an experimental work conducted on the digital storytelling – as part of the project Prin 2015 “Digital Interactive Storytelling in Mathematics: a competence-based social approach”¹. The key elements of the project are in a way expressed in its title’ single terms, which are briefly described below:

- *Mathematics*: object of learning. The focus is on the development of competencies in mathematics (Niss, 2003), starting from a specific mathematical content.
- *Storytelling*: the methodological context in which the teaching/learning process develops. The storytelling has been used since the beginning as a fundamental method enabling knowledge transfer. Its captivating power attracts the students at non-cognitive level of emotions and creativity. In addition, as they enter the story by playing one of the characters, the approach to storytelling is immersive, (Robin, 2008).
- *Interactive*: mode of learner’s participation. In the project, the student interacts with the story, he/she is not simply a listener. Actually, all his/her interaction influences the development of the story.
- *Digital*: the instrumental context in which the teaching/learning takes place. Everything happens in an online digital environment, including storytelling and interaction.

More specifically, the paper takes into consideration the immersive approach of the storytelling, and analyzes the way such an aspect can modify the type of students’ participation compared to how they usually behave in their traditional classroom. For the purpose of our analysis, we have focused on the following research questions: RQ1: How does the immersive approach of the storytelling

¹ This work is part of the project PRIN 2015 “Digital Interactive Storytelling in Mathematics: A Competence-based Social Approach”, funded by MIUR, effective from 5 February 2017.

influence learner's engagement in mathematical activities? RQ2: Can the immersive approach of the storytelling change the students' attitude towards Mathematics?

Intending to better explain our research theme, we have referred to a definition of "attitude" towards Mathematics, given by Di Martino & Zan (2007). This definition is based on the following three correlated concepts: learner's emotional disposal, revealed by the expressions "I like/I don't like"; learner's view of Mathematics, reflected by his/her beliefs "Mathematics is..."; learner's view of themselves as learners of mathematics (sense of self-efficacy), revealed by the expressions, "I'm successful/I'm not successful".

Theoretical background

This work integrates findings from different fields of research and, therefore, cannot be referred to a single theory. Below, we recall the theoretical aspects that are referred to.

Our activity design has mainly regarded collaborative learning, in particular the computer-based collaborative learning (Weinberger et al., 2009), where the need for pre-structuring and regulating social and cognitive processes is even more evident. To this aim, researchers in education have based their study on the concept of *script*, which refers to a sequence of actions directed to define a well-known situation (Schank & Abelson, 1977). Here, each actor has a specific role and specific actions to take part in, and the script is activated whenever one is in a similar situation. In didactics, scripts are imposed externally and support students in a collaborative/cooperative learning context through roles and actions they are required to play and carry out in order to succeed in learning (King, 2006).

The collaborative groups envisages a number of predetermined roles, each of them devoted to a given disciplinary function (Pesci, 2004) such as: *task-oriented*, responsible for all actions oriented to achieve the best result, *group-oriented*, responsible for the communication mood within the group, *speaker*, spokesperson, to speak on behalf of the group about all proposals, *memory*, responsible for saving a written recording of the achieved results, *observer*, responsible for observing all group interactions. Subsequently, a new role, born in the context of an *inquiry* approach (Arzarello & Soldano, 2016) has been added to the initial set, listed above, which we called *devil's lawyer*, i.e. a person who questions about what his/her classmates propose or say, and insinuates doubts.

Concerning mathematics instead, we have referred to the theoretical framework of story-problems (Zan, 2012) placing the mathematical structure in a situation with which the student is familiar and taking the form of a narration. In order to modulate the two dimensions in the text of the problem, Zan suggests the adoption of the C&Q model (Context and Question), as characterized by the following points: There is a story: temporal evolution of a situation, at least one animated character; There is a natural connection between history and question: a character with a purpose and context from which the mathematical problem arises in a natural way; The story is well structured: the parts of a text are linked together; the information has a "narrative" meaning.

A case study

The mathematical problem

In order to introduce the students to algebraic modelling, by reasoning and proving, we proposed the following mathematical problem (Iannece & Romano, 2008; Mellone & Tortora, 2015): “Take four consecutive numbers, multiply the second and the third numbers together and then the first and the fourth ones. Calculate the difference between the two products obtained. Repeat the exercise with four more numbers. Can you observe any regularity?”.

The students are expected to conjecture that the result is always 2 and to prove such a result through the algebraic representation of the generic four numbers as in the sequence n $n+1$ $n+2$ $n+3$, then the conversion of the given instructions as in $(n+1)(n+2) - n(n+3)$ and finally the treatment of the found expression, which determines the constant 2. The problem opens up questions of algebraic calculation, as well as linguistic and logical questions associated with terms such as “all” and “always”. It can also be used to stimulate students’ thinking on key mathematical concepts such as the meaning of “consecutive” numbers or the density of rational numbers in \mathbb{R} .

The story and its characters

The pedagogical model taken into account for creating the story is the C&Q Model of Zan (2012), as already illustrated in the theoretical background. The entire educational path and specifically the students are immersed in a story. The story, precisely, is set in a Science fiction situation, which sees a group of four friends engaged in the fairly unusual attempt to communicate with aliens from whom they had received mysterious messages made up of numbers and operations (Figure 1).

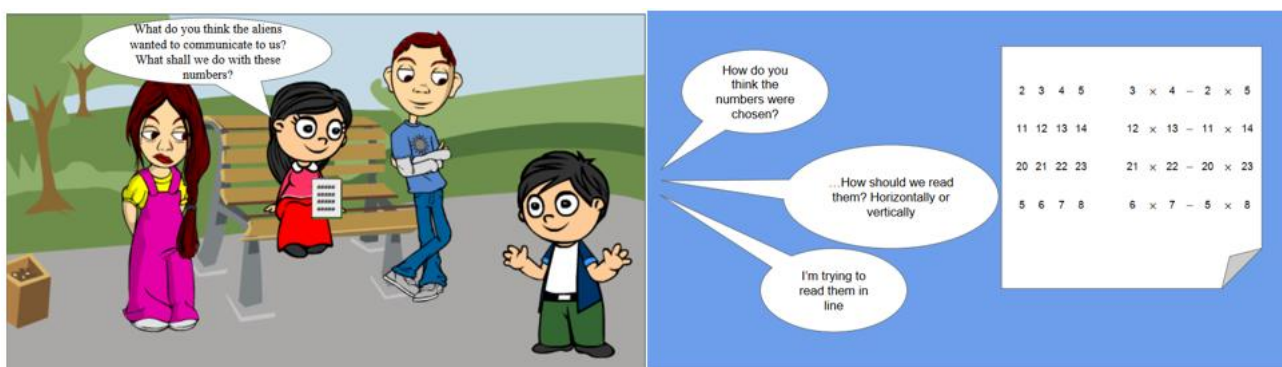


Figure 1: The problem

All roles used in the task, refer to those mentioned in the previous paragraph. It is important to note that the roles of *memory* and *observer*, involved in the activities conducted on digital platforms, are carried out by the platform itself that, at the same time, keeps track of everything happening in the group during the activity. Moreover, since the story makes use of technological tools, basing on previous experiences (Albano, Dello Iacono, & Mariotti, 2016; Albano & Dello Iacono, 2018), we have envisaged a new role, i.e. *technology-oriented*, able to support the teammates and to help them overcome possible problems arising from the use of technological tools. Our four friends correspond to the four roles provided: group-oriented, speaker, devil’s lawyer and technology-oriented, which all have been appropriately contextualised within the story as characters’ profile:

- Marco, called ‘the BOSS’ (i.e. the group-oriented), is the leader within the group of friends, and has won the trust of his teammates for his leadership behaviours;
- Sofia is passionate about reading and writing, she hopes to become a journalist and has got a craze for blogging. In fact, she is called ‘the BLOGGER (i.e. the group-oriented);
- Clara is a wary girl and constantly pesters her classmates with doubts and question; she is ‘the PEST’ (i.e. the devil’s lawyer);
- Federico is a computer enthusiast, convinced of the existence of extraterrestrial lives, he is always fiddling with electronic devices in search of alien signals. That is why he is called ‘the COMPUTER GEEK’, (i.e. the technology-oriented).

The four students of the group, within their Chat discussions, had to agree and chose an avatar that best represented themselves during the progression of the story, depending on the profile they saw as the most matching to their own features. Alongside the four friends, there is an adult, Gianmaria, Federico’s uncle, who is also an expert in computer devices and who loves mathematics. Gianmaria is a teacher/tutor’s avatar and acts as an expert in the learning process.

The story-problem starts with Federico who, fascinated by any possible life beyond the planet Earth, has developed an electronic device in the hope of capturing some signal from the distant sky. Finally, one day, a sequence of characters appears on the screen. (Figure 1). Unfortunately, during data reception the device breaks down and the message remains incomplete. Federico is so much curious as to involve his friends in this adventure, scanning and searching for a meaning to give to those signs and a way to communicate with strangers/aliens. In turn, to get help for the task, the four friends decide to involve their uncle Gianmaria, who accepts and offers them his support in solving the mystery. All interactions among the students and with Gianmaria guide the story flow (and the learning path), and lead them to hold communication with the aliens, after Federico has adjusted the reception device and connected it to their single smartphones. This new feature allows the aliens to send each of them a specific message, such that, in a second phase, they find themselves thinking about different sequences and discovering what they have in common (case of consecutive odd and even numbers, which lead to the number 8).

Methodology

The general aim of our work is to understand how the role playing and the actions carried out by the students in the Digital Interactive Storytelling environment impacts on their learning. In this paper we focus on the affective aspects of the students’ learning, that is on whether and how these elements can generate changes in their attitude towards mathematics.

The experimentation involved a 9th grade school class from a Foreign Language High School, consisting of 30 students, in the period April-June 2018. With the intention of investigating around our aim, the students were split into groups, each of them corresponding to the original group of the friends (characters) in the story. Each student in a subgroup took on one of the possible roles.

All students participated in the activity, interacting online, at distance, during extracurricular time. The meeting aroused engagement and shared intentionality by the classmates, and stimulated the participants’ interest in investigating the proposal presented by the researchers. In fact, after the meeting, the students could write an article in the school newspaper, in which they state among

other things: “We think this method is important, not only from a didactic point of view but also to keep us together and to engage those who usually do not take an active role during the classroom activities. The questions, asked in the form of comics, intrigued them very much, and that first meeting made them impressed” (Figure 2).



Figure 2: Students’ interaction with the problem story

Preliminary findings and discussion

This section focuses on the chat interactions of one of the groups of students who participated in the story. The initial step consists in an interview made to the teacher for the purpose of exploring her students’ engagement and attitude interacting with the problem story, and also receiving her perceptions of the changes possibly intervened in the students’ behaviours.

Let us read an excerpt of a Chat discussion. The role played by each student is reported in brackets:

- | | | |
|---|--------------------------|---|
| 1 | Dario (Boss): | What do you do? |
| 2 | Ivana (Blogger): | I’ m a blogger. |
| 3 | [..] | |
| 4 | Dario (Boss): | A Blogger cannot go any further than the Introduction |
| 5 | Ivana (Blogger): | How do I select characters? |
| 6 | Alessio (Computer geek): | Scroll down page then click on a blue dot and select |

In the excerpts 4-6, we can observe that Ivana faced with some technical issues, while Dario and Alessio intervened to: first, draw attention; second, help her, according to their own roles. Indeed, Dario takes care of engaging Ivana trying to explain how to solve her technical problems; to this aim he calls upon Alessio. Then, Alessio, playing his role of Computer geek, gives instructions on how to fix the problem.

Despite those initial difficulties, both technical and general, Ivana keeps acting her role: after Dario’s affirmation (rows 7-9 below), she synthesizes/reformulates what they expressed in the discussion; in the reformulation she moves from numerical to verbal examples allowing to describe all four cases.

- | | | |
|----|---------------|---|
| 7 | Dario (Boss): | 2 is the result of the first operation, i.e. $3*4-5*2$ |
| 8 | | and the results is $12-10 = 2$ |
| 9 | | all the operations are on the right, by doing them all we obtain 2 as a result. |
| 11 | | Thus one of the numbers is certainly 2 |

12 Ivana (Blogger): Yes, he has multiplied the product of the means minus the
13 product of the extremes.

A change in Ivana's attitude is also confirmed by the teacher's interview.

At the beginning, she did not expect Ivana to choose that role (row 12).

14 Researcher: Do the roles that the students chose reflect what you
15 would expect them to choose? Did their choices surprise you
considering the roles they normally have in the classroom?

17 Teacher: Ivana's role was a bit of a surprise since she has always
18 been an introverted girl.

Moreover, her changed engagement also impacted on her relationship with the teacher (rows 26-28) and with mathematics:

19 Researcher: Did you find the students involved in the digital activities were more
engaged than they generally are in other classroom activities?

20 Teacher: After the experience with the digital interactive storytelling, I noticed
21 a change in the way some students relate to me.

22 In particular, there were excellent results from a motivational and
23 emotional point of view: see for example Maria, Ivana, Rosaria whose
24 interaction and engagement in the platform had positive effects not
25 only on their advancement but also on the way they relate to
mathematics.

26 In a case, for instance, at first Ivana (Blogger) had refused to interact
with me, after I had asked her to solve an exercise on the blackboard.
At the end of this experience, she offered spontaneously to do it,
showing she was no longer afraid of mathematics....

29 Also Maria, witnessed her engagement by saying: "*Teacher, I have
surprisingly discovered another mathematics*".

Ivana's case was not isolated (rows 20-25). Other students changed their view about mathematics – see for instance what Maria said (row 29) – and also their attitude towards their teacher – see what the teacher perceived of the students' mood through Maria's words.

Furthermore, we investigated whether the students' engagement had somehow been linked to the assessment, asking the teacher if she had used such an element.

30 Researcher: Did you think to include an assessment session to engage students in
online activities?

31 Teacher: I have always told the students that the online activity is important
but

32 I would never use it as an evaluation activity. I would instead assess
each student on the ground of many elements, not only individual

tasks or questions, but the way they participate in the activities (in class or at home),

35 their attendance and attention.

The above teacher's words suggest that the online activity has been considered as part of a more global evaluation, which takes into account a general active participation in the whole path of didactics of mathematics during the school year. The conclusion that the evaluation had a very low impact is also justified by the fact that the students continued to participate in the activity even after the end of the school year (rows 44-47).

36 Researcher: Did you happen to intervene to prompt student's attention and/or
37 participation during the story evolution??

38 Teacher: Some groups did it spontaneously, others instead, needed to be
39 prompted– we can say that 3 out of 5 groups, moved
40 independently and 2 had some technical problems that required
41 my intervention and made them unable to hold their rhythm.

42 The highest number of notifications occurred after the end of the
school year, perhaps because the students had thought that the activity
was over

44 However, let me underline that the students, even though
45 no longer subjected to evaluation, have nevertheless continued to
46 interact within the platform being curious about the evolution
47 of the story.

Most of the groups involved in the activity proceeded autonomously during the activity flow, without being pressed by the teacher (row 38-39), and slow-downs were only due to technical problems.

Conclusion

In this work, we have meant to show significant aspects of a preliminary experimentation conducted on a designed digital storytelling in mathematics. The results show that the immersive aspect of storytelling, together with collaborative work and online interaction, typical of platform activities, may lead to a change in students' attitude towards mathematics (RQ2) and in their relationship with the teacher. Today, chat interactions are a familiar context for the students, and even those who get shy in face-to-face situations, may be active participants when interacting online (RQ1). Given the number of students involved in our case study, the results are clearly not generalizable. However, they allow us to identify both the potential of this type of interaction and scenario variables connected with the digital storytelling in mathematics. The interview made by the teacher confirms to be an interesting research methodology that allows us to reflect on other important variables, like the relationship between teacher and students. The preliminary findings will be considered in an experimentation project foreseen for the next phase (March 2019) of the PRIN Project that will involve many schools from different Italian regions. The preliminary results will be also used for

defining an adequate experimentation protocol that may enable us to validate our approach on a large scale.

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References

- Albano, G., Dello Iacono, U. (2018). DIST-M: scripting collaboration for competence-based mathematics learning. In Silverman, J., Hoyos, V. (Eds.): *Distance Learning, E-Learning and Blended Learning of Mathematics*, pp. 115–131. ICME-13 Monographs. Springer, Cham.
- Albano, G., Dello Iacono, U., Mariotti M.A. (2016). L'argomentazione in matematica: la mediazione attraverso il digital interactive storytelling. *Form@are - Open Journal per la formazione in rete*, Vol. 16(1), pp. 105–115.
- Arzarello, F., Soldano, C. (in press). Da Peirce a Hintikka (senza dimenticare Dewey): la logica dell'indagine in classe. In: F. Morselli, G. Rosolini, C. Toffalori (eds), *Educare alla razionalità. In ricordo di Paolo Gentilini*, Atti del Convegno di Sestri Levante 9-11 Giugno 2016.
- Di Martino, P., Zan, R. (2007). Attitude toward mathematics: overcoming the positive/negative dichotomy. *The Montana Mathematics Enthusiast*, Monograph 3, pp.157–168.
- King, A. (2006). Scripting collaborative learning processes: A cognitive perspective. In: F. Fischer, I. Kollar, H. Mandl, & J. Haake (eds.). *Scripting computer-supported collaborative learning: Cognitive, computational and educational perspectives*. New York: Springer.
- Iannece, D., Romano, P. (2008). *What does it mean to have a "scientific approach" for a teacher?* A reflection. Proc. of 5th international colloquium on the didactics of mathematics, Crete
- Mellone, M., Tortora, R. (2015). Ambiguity as a cognitive and didactic resource. In Krainer K., Vondrová N. (Eds.), *Proc. of CERME 9*, Praga, pp. 1434–1439.
- Niss, M. (2003). Mathematical competencies and the learning of mathematics: The Danish KOM project. *Third Mediterranean conference on mathematics education*, pp. 115–124.
- Pesci, A. (2004). Insegnare e apprendere cooperando: esperienze e prospettive, *L'insegnamento della matematica e delle scienze integrate*, Vol. 27 A-B(6) 6, pp. 637–670.
- Robin, B. (2008). *The effective uses of digital storytelling as a teaching and learning tool*. Handbook of Research on Teaching Literacy through the Communicative and Visual Arts, Vol. 2, pp. 429–440. Lawrence Erlbaum Associates, New York, NY.
- Schank, R., Roger, C., Abelson, R.P. (1977). *Scripts, plans, goals and understandings*. Hillsdale, NJ: Erlbaum.

- Sfard, A. (1991). *On the dual nature of mathematical conceptions: reflections on processes and objects as different sides of the same coin*. Educational Studies in Mathematics, Vol. 22, pp.1–33.
- Weinberger, A., Kollar, I., Dimitriadis, Y., Makitalo-Siegi, K., Fischer, F. (2009). Computer-supported collaboration scripts. *Technology enhanced learning*, Springer Netherlands, pp. 155–173.
- Zan, R. (2012). *La dimensione narrativa di un problema: il modello C&D per l'analisi e la (ri)formulazione del testo*. Parte I. L'insegnamento della matematica e delle scienze integrate. Vol.35A(2).