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Abstract This paper describes didactic and methodological choices on a course inspired by the story “The Seven Messengers” by Dino Buzzati. The aim is to investigate and introduce basic mathematics and physics skills. The project involves 35 students in the first year of the experimental “Liceo Matematico” school, promoted by the “G. Peano” Department of Mathematics of the University of Turin.

Keywords Robotics · Mathematics education · Mathematics and literature · Buzzati

1 Introduction

This paper describes a multidisciplinary didactic experience in mathematics and Italian literature that is based on the short story entitled “The Seven Messengers” by Dino Buzzati [1]. This idea has already been proposed by other authors [2], but the uniqueness of this version is the approach to the problem through educational robotics. The pedagogical principles of educational robotics can be found in the works of Seymour Papert [3, 4], who described the benefits of using construction and programming kits (in our case, Ozobots) for transforming students into creators of their own teaching tools and protagonists of their own learning. The strength of our teaching experience is, in my opinion, the introduction of robots to analyze and model a mathematical situation taken from a piece of literature.

The purposes are:

- To increase the time and quality of attention, compared to traditional lessons;
- To facilitate the learning of abstract concepts (space, time and speed) by representing them in a concrete context;
- To help students develop key scientific and linguistic skills by analyzing a literary text with a scientific theme.

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This didactic experience took place during the 2018/2019 academic year and involved 35 students (15 male and 20 female) attending the first year of Liceo Scientifico “L. B. Alberti” in Valenza (Alessandria). The students are part of the national “Liceo Matematico” project proposed by the University of Turin, whose purpose is to enhance excellence among high school students, and increase their interest in technical and science subjects at university courses. The didactic experiment took place in five lessons over nine hours (morning and afternoon) and involved two high school teachers: my colleague, a computer teacher, and me.

2 The Ideas in the Project

The teaching project is based on the short story “The Seven Messengers” by Dino Buzzati. Below is a summary of the story, which will help the reader understand our intentions. The students were provided with the original complete version of Buzzati’s text.

A prince sets out to explore his father’s kingdom and reach its outer frontiers. He takes with him seven messengers whom he sends back and forth between himself and the capital, to communicate with his family. To distinguish them more easily, he gives them these names: Alessandro, Bartolomeo, Caio, Domenico, Ettore, Federico, and Gregorio. As the days, months and years go by, the distance grows and communications become rarer. On the second day of the journey, the first messenger, Alessandro, returns to the capital. Meanwhile, the prince and his caravan continue traveling at a constant speed. In the following days the other messengers, Bartolomeo, Caio, Domenico, Ettore, Federico and Gregorio, leave consecutively following these rules: as one messenger catches up with the caravan (in the evening), he delivers the news to the prince, stops for the night and departs again in the opposite direction. The messengers travel at one and a half times the speed of the prince’s caravan.

After reading the original text, we give the students two questionnaires. The first is on the textual analysis of the story and contains these questions:

1. What elements are relevant to understanding the text?
2. What elements are relevant to understanding it from a logical point of view?
3. Are there any elements in the story that explicitly refer to the fields of mathematics and physics? If so, do you consider these elements to be essential to your understanding of it?

The second questionnaire, on mathematics, has the following questions:

1. After how many days, from the start of the journey, will Alessandro be back?
2. More generally, if a messenger leaves on the n th day, what day will he return?
3. After how many days, from the start of the journey, will each of them be back?
4. Can the sequence of departures be expressed in a mathematical formula?
5. In the story the prince says he has traveled uninterruptedly for eight years, six months and fifteen days. How many leagues does he travel?
6. How many leagues do the seven messengers travel?

It took the students two and a half hours to complete the questionnaires (plus half an hour to read Buzzati's story) across two lessons. The remaining six hours were dedicated to "translating" the story through coding and robotics. Seven Ozobot robots simulated the seven messengers and one Ozobot was the king's son. Buzzati's short story was also transposed into a Scratch game. The students programmed the Ozobots to recreate the departures and speeds of the seven messengers. These data can be obtained directly from Buzzati's story and are the added value, and the innovation, of the teaching proposal. Indeed, this task requires students to have fully understood the story's mathematical elements and have transposed them into physical terms (i.e., distance covered and time spent). They should also have worked out the mathematical law that governs the messengers' departures and arrivals. These skills combine logical, mathematical, and also linguistic skills. The project goes even further by asking the students to apply these skills to writing the appropriate commands for the Ozobots in the programming language. The game was created in Scratch in the remaining hours of the project.

3 Educational Impact and Critical Analysis

Understanding the text of mathematics problems has always been one of the biggest obstacles to solving them. This educational project is an invitation to look beyond mathematics to language for ways to overcome this obstacle. The students analyze a narrative text to get mathematical information from it. The goal is to help students analyze a mathematical problem with a lengthier text than usual, and extrapolate problems from reality. Unexplained text information is exclusively mathematical and the second form should be used to focus on them. The students had no trouble determining when the first messenger, Alessandro, would return, because the original text states explicitly that the prince's caravan travels at 40 leagues a day, and the messengers travel at one and a half times the speed of the prince (60 leagues a day). However, imagining the messenger's path is less simple. Alessandro has to return to the castle (80 leagues), then go back to the point from which he started (another 80 leagues) and finally catch up with the prince, who has continued to walk at a speed of 40 leagues a day. The students suggest at least three possible approaches to this problem: *empirical* (simulating the path of the prince's caravan and the messenger on paper); *algebraic* (looking for the relationship between the messenger's progress and the caravan's progress); *physical-algebraic* (creating an equation of motion between the caravan's rate of travel and the messenger's).

Students understood that analyzing the text in logical and literary terms is key to their formulating the correct answers and the most appropriate mathematical approach. In fact, students used the physical-algebraic analysis of the rate of departures and returns and the journey times to answer up to the fifth question: they only have to multiply by five the number of the day on which the messengers left the prince to get the number of the day of their return from the castle (Fig. 1). The last two questions on the second questionnaire are easy to solve and open up possibilities for

Fig. 1 Equations of motion for all messengers: diagram of the first 40 days

further interdisciplinary links. To find out how many leagues the prince has traveled, students have to decide how many days there are in 8 years, 6 months and 15 days. They pointed out the two leap years, and counted the six months with only 30 days in them, to reach a total of 3117 days. This reasonable hypothesis clashes with Buzzati's original text (*Domenico's return on the last day of the journey*) because, according to the calculations, Domenico should arrive on the 3125th day. It was fascinating to see the students' attempts to get past this discrepancy, by hypothesizing that the journey could have started at the end of a leap year, hence there would be three leap years in eight years of travel.

After this discussion, the students focused on robotics. The decision to transpose the story using Ozobots (Fig. 2) was made because the school had used these robots for several years for coding and block programming, and also to practice their mathematical skills. As they use the Ozobots, students develop a critical ability

Fig. 2 An Ozobot in action on a path created by a student

to appreciate their advantages and disadvantages. Ozobots also represent the active construction of knowledge through interaction with the world: students learn by manipulating objects [5] whose movements are decided in a simple programming language (Ozobots use a block programming language called Blockly that is very similar to what is used in its more famous counterpart Scratch¹).

Ozobots are golf-ball-sized transparent spheres that can move along colorful paths, on paper or on digital surfaces. Students recreated the kingdom on paper and programmed seven Ozobots as the “messengers” and one as the “prince” moving at different speeds. They also decided that the programmed Ozobots should simulate the messengers’ departures and arrivals during the first 40 days of the journey (Fig. 1).

Introducing robotics also increased inclusivity. Each student, including those with special needs, was assigned a specific role during the creation of the map of the kingdom. The robotics-related activities also helped all the students to learn how to handle errors virtuously. Errors were not seen as failures, but rather were exploited by all (teacher and students) as a learning tool that helps them try out new strategies and find the right solution. Errors move to the emotional dimension where, as is known from pedagogical research, they play a fundamental role in the knowledge process [6]. I believe this cross-disciplinary experiment involving mathematics and literature has had an impact on the emotional sphere of students, adding to their ability to solve non-trivial problems and also to think creatively. Assigning specific roles to all students based on their unique potential makes each of them responsible for their work and also helps students with special educational needs to reason more flexibly in unforeseen situations [7].

4 Final Remarks

This educational path differs from others where mathematics is a technique, pure syntax, separate from any historical or applicative context. Our approach to a mathematical problem involves transdisciplinary and transversal skills. Robotics is a resource that could be used more widely in teaching to solve mathematics (and physics), but should be applied with caution. The history of education in mathematics is littered with examples of what appear to be miracle tools and materials that are soon forgotten by teachers themselves [8]. If teachers reflect on the teaching and learning process, robots can serve as “objects with which to reason” [4, 9]. Indeed, as Damiani [10] argues, the body and the ability to manipulate are key not only as sensory mediators between the brain and the outside world, but also as the main device by which to learn and produce knowledge. According to Polya [11], solving problems is one of the most important activities of humans, which is why we teachers must offer our students numerous different contexts in which to mobilize solution strategies.

¹ <https://ozoblockly.com/>.

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