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In this communication, we present the experience that was carried out during the 2021-2022 academic year in a Spanish public university with Primary Education teachers in training who were in their second year. It consisted of four activities in which proportionality problems (mathematical content) and pure substances and mixtures (experimental science content) were worked simultaneously, contextualized in an organic learning garden. In this paper, we present two of these activities and carry out an analysis of the students' responses. The results obtained allow us to detect deficiencies and difficulties in the use of measuring instruments and in the calculation of proportions. This allows us to consider the need to develop strategies to support students in their training process.

Keywords: Primary education, initial teacher training, mathematics education, STEM education, organic learning garden.

Introduction

In the training of future teachers, it is necessary to work on mathematical competence in the sense presented by the OECD (2004) so that they can subsequently transmit into their future students. For this, it is necessary to work on mathematical connections, which Alsina (2014) defines as the relationships of mathematical contents and processes, the relationships of mathematics with other areas of knowledge and the relationships with the environment around us. Thus, Alsina (2020) argues that mathematics can be worked in connection with science, technology, engineering, art, etc., giving rise to STEAM (Science, Technology, Engineering, Art, Mathematics) education. This term has its origin in the STEM approach (Rocard et al., 2007, p. 5), which consists of an interdisciplinary teaching that applies knowledge of science and mathematics to work on basic competencies of both areas.

We intend to foster STEAM literacy, in the sense of Couso (2017), by promoting the teaching of mathematics and experimental sciences through problem solving (Beltrán-Pellicer & Martínez-Juste, 2021). For this purpose, we will use a garden located at our university similar to the gardens that are present in educational centers for childhood and elementary schools. We call it an organic learning garden since it has a formative character. Learning based on the garden from a joint perspective of both subjects is a type of learning that, despite the scarce theorization that we have found in a review of the literature (Monferrer et al., 2022), constitutes an alternative to study content of various subjects in an interdisciplinary and contextualized way.

The use of this outdoor learning space opens up the possibility of creating a new learning situation, different from the one experienced in the classroom, and allows students to solve problems different from those they have learned in the class. Studies such as that of Bransford et al. (2000) confirm that students of all academic levels have great difficulties in applying what they have learned in the conventional classroom to situations or problems not directly related to what they have just learned.

After reviewing the contents of the mathematics curriculum for elementary school, we can highlight that, in the sixth grade, "proportionality problems" are worked on. These contents seem relevant to us for two reasons; the first one because these types of problems are the culmination of arithmetic (Santágueda & Gómez, 2021) and the second one because we found studies such as the one by Valverde (2008) where it is stated that it is one of the most difficult contents for teachers in training.

In relation to the area of experimental sciences, we can highlight that block 4 of "matter and energy" addressed to students who are 11-12 years old in the Spanish education system (Real Decreto 157/2022) presents the contents of "pure substances and mixtures". The contents of both subjects can be related to each other in a natural (or fluid) way in a garden context.

This paper shows an experience in which teachers in initial training were able to carry out a transfer of learning based on the works of Gómez et al. (2012) on didactics of mathematics and didactics of experiments science in the organic learning garden. With this, we intend to make students aware of the benefits of this resource, which will surely be within their reach, when they become practicing professionals. The objectives of the research are:

1. To present a real learning situation to work together mathematics and experimental sciences.
2. To analyze the solution processes used, errors and difficulties presented by university students when solving the problem within the learning situation.

Methodology

Study design and participants

The methodology used was action research based on Martinez-Juste (2022). Our intention was to reflect on the practices with our university students, both in order to improve their practices (McNiff, 1992) and to show the students how to work interdisciplinary between two subjects (i.e. experimental sciences and mathematics). The researchers of this study are also teachers of these subjects, so the agents involved were reduced. We carried out the action research in four phases: planning, action, observation and reflection.

In the planning phase, various activities were designed in experimental sciences and mathematics to work in the organic garden. The solution of two problems based on proportionality were proposed similar to Rodríguez and Pereiara (2016).

In the action phase, the students went to the organic learning garden where various activities were carried out.

The observation phase consisted of two periods, the first one carried out in the organic learning garden and the second one consisted in the cognitive analysis of the written productions performed by students in the tasks. It was focused on learning difficulties, errors in the tasks and solution strategies of students based on Cañadas and Castro (2013).

Finally, in the reflection phase, the teachers analyzed the students' written productions obtained in order to improve teaching through an instructional analysis where the strengths and weaknesses of our proposal are determined (Martínez-Juste, 2022).

Participants

The sessions were attended by 60 students from the 2nd year of the Bachelor's Degree in Primary Education at the University Jaume I of Castelló (77% males and 23% females), who were enrolled in the subject Teaching Mathematics I. Their ages are, mostly, 75%, in the natural age that corresponds to them per academic year, 19 years. 18% of people are 20 years old and only 7% are older than 20 years. Except for one person, the rest have completed High School in the following modalities: Arts, 3%; Humanities and Social Sciences, 32%; and Sciences and Technology, 63%. Most of them, 90%, studied Mathematics; 28% Biology and only 18% studied Chemistry in High School.

Procedure

Once the planning phase had been addressed, the action phase was followed by the observation phase. For this purpose, a session in the organic learning garden which included four activities (30 minutes per activity) was performed, here we present two of them. Knowledge from the two subjects (i.e. mathematics and experimental science) were combined within these activities. In mathematics, measurement and calculations of proportions and in natural sciences, preparation of mixtures from pure substances related to fertilizing the land, to calculate germination rate and to prepare garden care products.

The students organised themselves into groups of four to carry out the activities. They were provided with introductions to each task and could take notes throughout the session.

The two activities that we present in this work are shown below. Table 1 shows the learning goals to be achieved through activity 1, while table 2 shows the learning goals for activity 2.

Activity 1: For plant roots to grow well, it is advisable to aerate and fertilize the soil. For this reason, we need to make a mixture of fertilizer and soil. Taking the proportion between both components is 3 kg of fertilizer per m^2 of plot into account, calculate:

1. The area of the plot to be fertilized, with the measuring instruments that you consider.

2. Once you have the square meters of it, calculate the kg of fertilizer that is needed to completely fertilize this area.

Table 1: Objectives of activity 1

Experimental Science learning goals:	Mathematics learning goals:
1. To know the importance of supplying nutrients to crop plants. 2. To know the different types of fertilizers.	1. To delimit the plot and measure the width and length of the plot to be fertilized. 2. To calculate the area of the plot to be fertilized. 3. To calculate the proportion of fertilizer to use.

Activity 2: In areas where there are crops, in addition to plants, there are also invertebrate animals, most of which are insects. One of the most common insects that is usually observed in crops is the aphid. When conditions are optimal, population growth causes a plague. One of the ecological remedies to control its population is the use of potassium soap. Given that 2% potassium soap is required for use in the crop and that we have a stock of 10%, prepare a 500 ml bottle to fumigate the garden.

Remember that you can use the following formula.

Initial Concentration x Initial Volume = Final Concentration x Final Volume

At the end of the activity, students conduct a brief guided discussion on the use of pesticides and their consequences for the environment.

Table 2: Objectives of activity 2

Experimental sciences learning goals:	Mathematics learning goals:
1. To know some of the animals that usually inhabit the growing areas. 2. To investigate what conditions encourage the appearance of pests. 3. To know the consequences of the use of harmful pesticides for the environment. 4. To raise awareness about the use of environmentally friendly alternative remedies. 5. To prepare a natural remedy to control pests.	1. To calculate the inverse proportion.

Data analysis

After the observation phase, we conducted the reflection phase. For that, we analyzed the data from the mathematical problems with a mixed research methodology, which combines quantitative and qualitative analysis as done in Hernández et al. (2010). Quantitatively, the success rate in solving each problem was analyzed and qualitatively adequate strategies to solve the problems were identified. To this end, a content analysis has been carried out (López, 2002, p. 177) investigating the students' written productions and we built categories from an inductive approach and the aforementioned theoretical framework (Berg, 2007, p. 24). The fact that four researchers acted on all the documents produced by the students improves the validity and reliability of the conclusions (Hernández et al., 2010).

Results

Regarding the first activity, all groups solved it correctly: specifically, 9 groups (56.25%) solved the problem using basic arithmetic methods (they operated using multiplications, see Figure 1 - left), 1 group (6.25%) solved the problem using proportions (see Figure 1 - center), and 6 groups used a rule of three to solve the proportion (see Figure 1 - right).

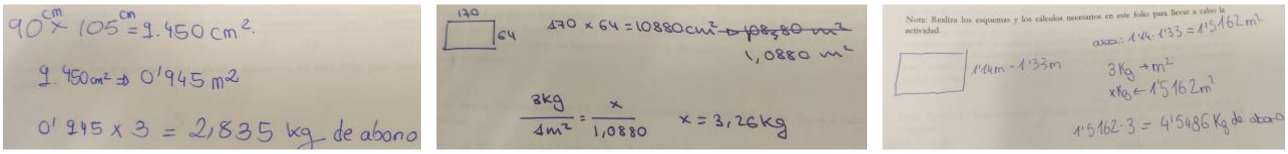

Figure 1: Different approaches to solving the proposed problem. Left multiplications, center proportion and right rule of three

We provide each group with one of the parcels of a different size than they had to fertilize (see Figure 2), and we observed difficulties in the use of the measurement instruments. Some of the groups did not use the scale that we provided them correctly and we also observed that they did not carry out strategies to weigh about three kilograms of fertilizer on a small scale. There were also groups that did not know the tools to work the land.

Figure 2: Participants carrying out activity 1

The next problem was easy since we provided them with the formula, and the only possible error was solving the equation, but since they worked in a group and were supervised by teachers, this did not occur. An interesting fact was that most of the groups did not use percentages (68.75%), but rather worked with whole numbers (see Figure 3 - right). While the rest (31.25%) conceived the percentage as a fraction and worked with its equivalent to decimal (e.g., 2%=0.02 and 10%=0.10) introducing these numbers in the formula provided (see Figure 3 - left).

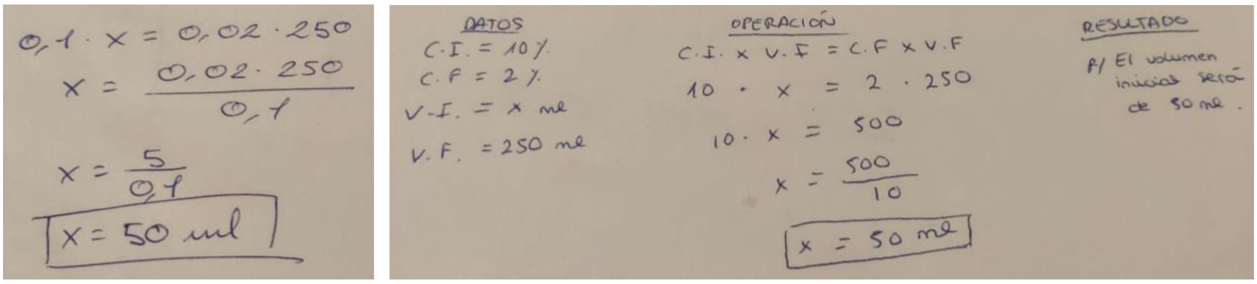

Figure 3: Calculations performed to solve activity 2

In the practical part of the experience (see Figure 4), although the use of the test tubes was apparently easy, we found that around 50% of the students had never used them and it was difficult for them to identify the graduations.

Figure 4: Preparation of the organic product of activity 2

The conclusion in the reflection session, which took place in the classroom with the students, was that the experience had been fun and relaxing, that they did not have so much pressure when they solved a problem in the garden, because they were more relaxed and some even said that they were more safe and confident. In addition, the students commented that the contextualization of the problems in a realistic environment where, besides to solving it, they had to apply it, motivated them and made the role they acquired more truthful.

All the groups concluded that it was an interesting way of presenting situations of measurement, use of materials, and to work on the change of units in a real context. We would like to comment that some students said that when they went to school and they had to use the change of units of the International System it did not make any sense for them, but that in the applied context of the garden they had understood it. In the case of proportions, the students thought that the use of contextualization also facilitated their understanding.

Discussion

In the learning situation presented, we have tried to work on the transfer teaching-learning process in line with Gómez et al. (2012). The final reflection was very useful since students reported that they found this experience interesting while they were learning. In addition, in that session, we were able to generalize content and delve into aspects of both subjects.

This experience involved an interdisciplinary learning situation in a real context and outside the classroom. The organic learning garden gives us the possibility of carrying out actions of this type, and it may motivate our students in training to use the organic garden with their future students. Our study partially concur with Bransford et al. (2000) who observed difficulties, especially in the use of the measurement instruments. We consider that the presented experience can help students to solve these difficulties. STEAM literacy has been promoted (Couso, 2017) to help students discover a space where they can create learning situations from interdisciplinary teaching (Rocard et al. 2007) and it has been shown that mathematics and experimental sciences can be worked together through of problem solving (Beltrán-Pellicer & Martínez-Juste, 2021).

The implementation of this type of experience should consider several key aspects in order to be carried out successfully, such as the weather as these are outdoor activities and the need of multiple researcher-teachers (at least 4) to guide the students in the activities. In addition, it would be interesting to conduct similar future studies that include a larger sample.

The learning situations in the organic learning garden favour significant and real learning in teachers in initial training, who should then be able to transfer this knowledge to their students in the near future. In order to address the difficulties found in students' learning, we would like to continue performing teaching-learning experiences of this type which work other mathematics and experimental science contents together (e.g. proportions and healthy eating).

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