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Teaching the Plant Kingdom Using Cooperative Learning and Plants Elements: A Case Study with Spanish Secondary School Students

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ABSTRACT
The plant kingdom can be learned more successfully if tasks involve direct contact with elements of the plant world and students have the possibility of working cooperatively in small groups within the secondary school classroom. This paper analyses student understanding of the general and floral physiology of angiosperms within a teaching-sequence in which cooperative learning was applied to 74 Spanish secondary school students aged 12-13 years. The influence of group work and the use of plant elements on learning was assessed by comparing two tasks administered individually before and after the sequence. Subsequent application of Fisher's exact test detected statistically significant differences between the two milestones in favour of cooperative learning and the use of plants. We can therefore conclude that this active method for learning the plant kingdom enables students to get physically closer to the subject of the plant kingdom whilst developing their scientific knowledge via group work.

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Introduction

Over many years, two independent approaches with interesting advantages for learning biology have appeared in the literature. The first approach involves performing real-life (kinesthetic) experiences in a natural setting (Sampson, Clark, 2008) and the second involves cooperative learning, which provides collaborative opportunities for biology students (Johnson et al., 2000; Springer et al., 1999).

Contact with the natural environment is essential when teaching biology in order for students to develop a thorough understanding of the subject (Rachmatullah, Ha, 2018; Sampson, Clark, 2008). For instance, when learning about plants, students can observe, touch, and smell them, which are important for people who live in cities to learn more about the natural environment around them (Louv, 2008). Some examples of this type of education can be found in Montessori's pedagogy (Durakoglu, 2014), which seeks to use natural resources in classroom teaching processes, thereby developing socio-natural values, which are considered necessary for comprehensive training, while working on the topics (Velásquez, 2005).

With regards to the use of real plants in the teaching process, people tend to ignore plants as living organisms and underestimate them when compared to animals (Amprazis et al., 2019). This phenomenon is known as plant blindness and can be defined as the inability to notice plants in one's environment, recognize their importance, or appreciate their unique biological features (Wandersee, Schussler, 2001). The use of real plants provides students with the opportunity to understand and experience them and prevents them from becoming plant blind. As such, it is essential for new generations to understand the importance of plants for the planet and for humans (Jose et al., 2019).

Similarly, engagement with nature via indirect contact with involvement in certain nature-related activities has been shown to play a role in predicting pro-environmental behaviours such as noticing everyday nature, sharing with friends what emotions nature evoked, creating art from nature, and eating wild plants, for example, being important for increasing nature connectedness (Richardson et al., 2020).

In recent years, various researchers have shown the potential of cooperative learning in the school learning process (Akçay, Doymus, 2014; Essien, 2015; Hsiung, 2012; Igel, Urquhart, 2012; Ke, Grabowski, 2007; Tran, 2014; Tsay, Brady, 2010; Zahara, Anowar, 2010). Cooperative learning is a type of active learning (Adams, Hamm, 1994; Johnson, Johnson, 2008) that focuses on solving problems via team work and interstudent interactions (Ajaja, Evanwoke, 2010; Sharan, 2010). Cooperative learning structures students into groups, with defined or undefined roles for each student, and a task for the group to accomplish (Bernal, Martínez, 2009). It can be defined as a methodology based on (usually) small and heterogeneous group work in which each student works to improve their own learning and that of the other members of the group by taking advantage of the maximum interaction between them, with the ultimate goal that everyone learns, irrespective of their characteristics or abilities (Armstrong, Palmer, 1998; Springer et al., 1999). Moreover, cooperative learning allows students to control their learning, thus permitting them to actively participate in the learning process (Johnson et al., 2000).

To sum up, cooperative learning principles involve: (1) positive interdependence and interaction, (2) individual accountability, (3) face-to-face interaction, (4) social skills, and (5) evaluation of group processing (Altun, 2015; Johnson, Johnson, 2008; Macpherson, 2015).

Cooperative learning is not a new concept. Indeed, it dates back to the early years of the 20th century, when Dewey stated that the role of an educator was to prepare students for democratic citizenship by submerging them in real-world problem-solving using collaboration and their imagination (Benson et al., 2007). This methodology enhances learning of all types of students. Thus, when working individually, weak students are likely to give up if they get stuck, whereas when working cooperatively they can keep going. Similarly, when faced with the task of explaining and clarifying material to weaker students, strong students often find gaps in their own understanding and fill them in. Moreover, when working alone, students may tend to delay completing assignments or skip them altogether, but when they know that others are counting on them, they are motivated to do the work in a timely manner (Felder, Brent, 2007).

Despite the availability of results from a large number of studies, controversy still exists about the effects of cooperative learning (Lord, 2001; Watson, 1991), with teachers who attempt it frequently encountering resistance and, sometimes, open hostility from students. Knowledgeable and patient instructors find ways to deal with these problems (Felder, Brent, 2007; Shimazoe, Aldrich, 2010).

In our opinion, the advantages presented by these two approaches individually (real-life experiences in a natural setting and cooperative learning) could be enhanced by using a combined methodology for teaching/learning biology in secondary schools, an aspect that has received relatively little attention in this field. As such, this study aims to explore 8th grade Spanish students' understanding of the plant kingdom in a teaching sequence in which active learning is used. Specifically, this study is intended to analyze the impact of cooperative active learning in contact with plant elements from the natural environment.

Our hypothesis is that the use a combined methodology involving cooperative learning through real-life (kinesthetic) experiences could help improve learning and understanding of the topic by helping students to develop their social skills in order to become better citizens.

Theoretical Framework

Teaching the Natural Environment

An important aspect to highlight in the teaching of biology, especially as regards learning about the plant world and nature, is the passivity that characterises traditional teaching when addressing this topic in the classroom. In addition, students present some difficulties as regards understanding some plant-related aspects, such as germination (Vidal, Membiela, 2014), pollination (Baranzelli et al., 2018) or seeds (Jewell, 2002).

Contact between modern society and the natural environment is decreasing (Sampson, Clark, 2008), thus resulting in a decrease in the interactions between students and their natural environment. As such, there is an urgent need to include this in the educational curriculum (Dadvand et al., 2015) since science cannot be taught effectively without a thorough understanding and knowledge of the parts studied.

In this regard, Louv (2008) introduced the concept of "nature-deficit syndrome", relating it to a deficit in students' contact with the natural environment, which results in problems as regards the development of children and adolescents. Different studies have demonstrated that contact with the natural environment, and plant elements from it, helps to control children's attention deficit disorder and hyperactivity problems. Indeed, involving nature in children's development provides them with spaces for discovery where they are able to take risks and develop their imagination and their ability to solve problems whilst improving the coexistence between them (Dadvand et al., 2015). Furthermore, this contact with nature has been found to reduce stress, which provides them with a better ability to manage life challenges and facilitates more interactions with friends and neighbours (Wells, Rollings, 2012). This contact with the environment is very important when studying the plant kingdom. The literature shows that learning is done through interaction of the student with the environment, making direct reference to the plant elements that form part of. Learning Montessori's practical life exercises (Durakoglu, 2014), such as the cultivation of plants and the care of farm and domestic animals, is a clear example of this. In short, performing outdoor play activities has a positive impact on learning (Giardiello, 2013). Consequently, children who grow up observing animals and plants develop a conscience for those organisms whilst increasing their love and respect for nature and living things in general. At the same time, students could gain a new point of view in which plants are seen to be living organisms that are important for us and for the planet (Jose et al., 2019).

Cooperative Learning in Science Education

Different studies have shown how cooperative learning can increase students' performance in science education (Bara, Xhomara, 2020; Freeman et al., 2014; Mujassam et al., 2018; Okur, Doymus, 2014). Thus, the literature shows that students achieve better academic success in science in general (Arbab, 2003; Zakaria, Iksan, 2007), and in biology in particular (Lord, 1998; Watson, 1991). Moreover, this methodology helps to enhance both the understanding of biological knowledge and scientific skills (Chatila, Husseiny, 2017), and developing positive attitudes in this field (Rabgay, 2018).

The study by Lord (2001), which analyses 300 articles concerning teaching science using cooperative learning, is a reference work in the field of biology teaching and concludes that the use of this methodology allows the development of scientific thinking and attitudes, a better understanding of instructions, evaluation, values, the learning environment, and practical skills and social skills, and enhances all these aspects, thereby improving scientific reading and writing skills and modelling real life learning in women and men equally. According to Day & Bryce (2013), interstudent communication, organization, self-esteem and confidence building are some of the social skills which can be developed through cooperative learning. Similarly, this method creates sensitive students who are able to reflect on the real world from a scientific viewpoint (Zakaria, Iksan, 2007). Moreover, in science lessons, students will be able to develop higher-order critical thinking skills and independent thinking, thus giving them the opportunity to explore new ideas proposed by peers who share their views, and improve their scientific problem-solving skills and their collaborative work capacity (Abdurramhan, et al., 2019; Ajaja, Evanwoke, 2010; Shimazoe, Aldrich, 2010). This is possible thanks to the multidirectional dialogues based around scientific content and the group work that enables learning interactions between the students (Day, Bryce, 2013; Gillies, 2006).

Active teaching-learning techniques cover a wide range of activities on a continuum from simple to complex tasks (Van Amburgh et al., 2007). One interesting proposal for cooperative learning in a biology class is known as Student Team Learning (STL) (Slavin, 1995). This method is based on students' development of the group learning process. According to different studies, the STL method increases the motivation of students, and therefore their engagement and academic achievement (Gul, Shehzad, 2015). It also encourages students to develop other social behaviors, such as team-based skills, mutual interdependence and the skills to build a coherent and integrated identity (Khan, Inamullah, 2011). Specifically, in science education, this method improves science process skills and enhances the teaching of higher-order thinking skills and team-based skills (Frame et al., 2015).

STL techniques are chosen depending on the needs of the specific group of students and the subject. One interesting technique is the Student Teams-Achievement Division (STAD) (Felder, Brent, 2001), in which the teacher presents certain skills or content to students, then they subsequently work as a team to ensure that everyone has learned what the teacher presented by using different worksheet or exercises proposed by the teacher. Finally, a test is administered individually to check the improvement of each student. The final score is a compendium of aspects they have worked on as a group and individually (Slavin, 1995).

Despite the popularity of cooperative learning, Bennett et al.'s review (2010) showed that comparatively few details are known about their use and effects of small group discussions in high school science teaching. According to Bennett et al. (2010), *"students often struggle to formulate and express coherent arguments, and demonstrate a low level of engagement with tasks* […] *…groups function more purposefully, and understanding improves most, when specifically constituted such that differing views are represented, when some form of training is provided for students on effective group work, and when help in structuring discussions is provided in the form of 'cues'".*

For these reasons, a new empirical study with high school students is presented in this paper since we cannot be sure that the collaborative learning plus use of plants approach will work given that prior research evidence is not clear.

Methods

This study was performed from a qualitative and quantitative perspective, with a case-study design (Yin, 2003).

Participants

This paper reports a case study about the plant kingdom using STAD as cooperative active learning for grade 8 in the teaching sequence entitled "The plant kingdom". This study was conducted with 74 students from a high school in Málaga (Spain) in 2018. Convenience sampling, in which participants were selected on the basis of their easy accessibility, was used since the lead author of this paper was teaching biology to these students. Students were assigned to three groups, two of them which comprised 25 students and the third 24. Of these, 63% of students were girls and students' ages ranged from 12 to 13 years. There were five different nationalities in the group (82% Spanish). The economic level of the families differed markedly between students, thus forming a highly heterogeneous group in terms of this variable.

A Teaching Sequence about the Plant Kingdom

The teaching sequence meets the curriculum objectives in Spain (MECD, 2015), which can be summarised into the learning objectives shown in Table 1 using the three major categories proposed by Hodson (1992), namely "learning science", "doing science", and "learning about science".

Table 1

Learning Objectives of the Teaching Sequence

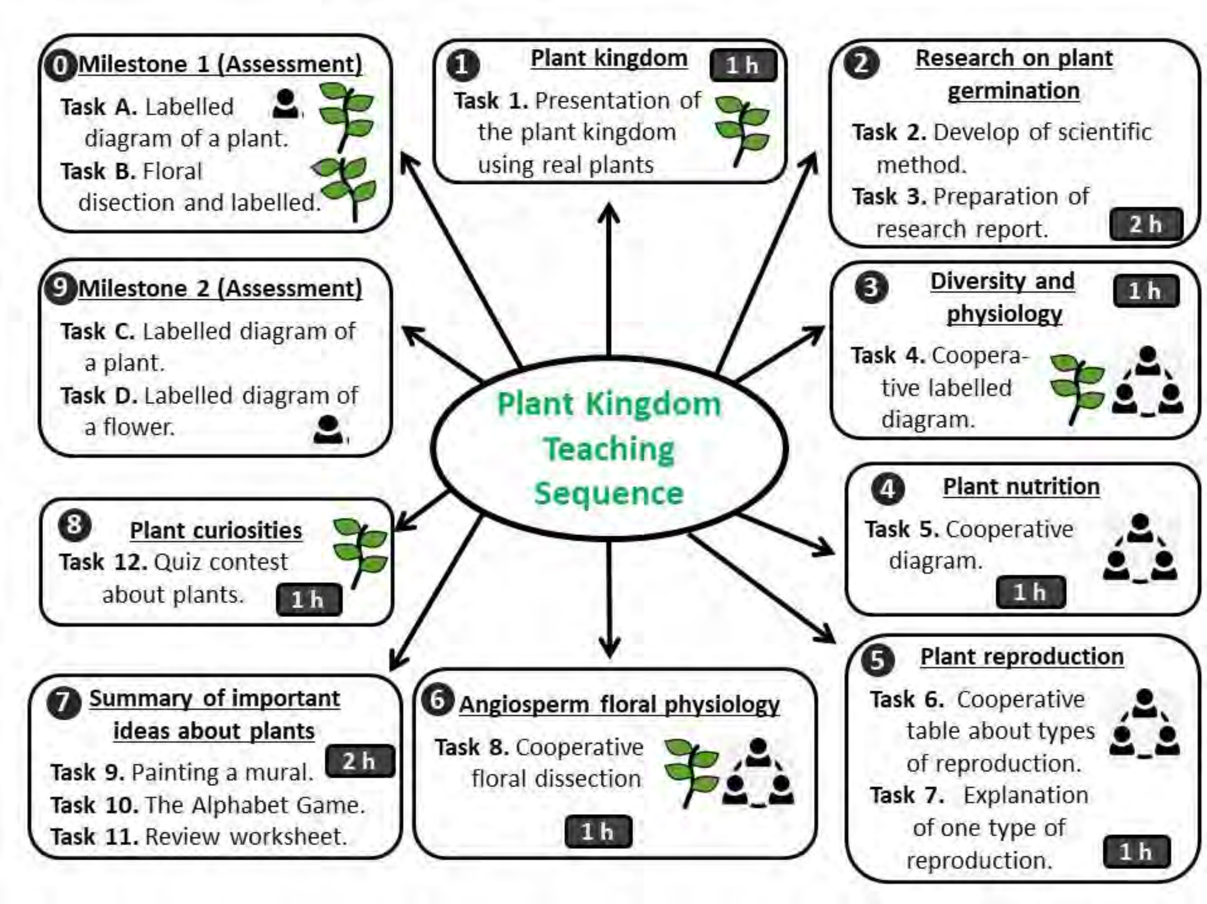
Learning Objectives Category (Hodson, 1992)	Sequence Content as Student Learning Outcomes: Students Will Be Able To	Task
Learning Science	1.1 Know the different types of plants.	1, 4
	1.2 Understand the vital functions of nutrition and reproduction in plants.	5, 6, 7
	1.3 Understand the main characteristics of plant physiology (leaves, roots, stems).	4
	1.4 Know the different parts of angiosperm flowers and their functions.	8
	1.5 Know the basic characteristics of the scientific methodology in research on plant germination.	2,3
Doing Science	2.1 Obtain information about germination of a plant.	2, 11
	2.2 Explain the processes of nutrition and reproduction of plants.	5, 6, 7, 9, 12
	2.3 Propose a hypothesis, collect data and present results about plants.	2, 3
	2.4 Prepare schemes, explanatory drawings and diagrams about the different parts of plants and angiosperm flowers.	8, 9, 12
	2.5. Perform a floral dissection.	8
Learning about Science	3.1 Be sensitive about plants.	1, 11
	3.2 Take actions that favour the conservation of plants.	1, 10, 11
	3.3 Demand plant elements and organisms in their daily life.	10, 11

The teaching sequence was taught in 10 1-hour lessons in which a total of 12 tasks (1 to 12) were performed, along with four evaluation tasks (A, B, C and D). The tasks in the teaching sequence are summarized in the concept map shown in Figure 1, which also includes the evaluation tasks used as pre- and post-test (see upper left corner in Figure 1).

The 12 tasks were divided into the following plant-related topics (Figure 1): presentation of the plant kingdom using real plants; research on plant germination, diversity and physiology; plant nutrition; plant reproduction; angiosperm floral physiology; summary of important ideas about plants; and plant curiosities. The different learning outcomes for each task can be seen in Table 1. Figure 1 also includes icons for some tasks. Thus, the leaves icon refers to the term plant elements, which indicates that real plants were used during the task, the single-person icon is associated with activities that students performed individually, and the three-person icon indicates activities with cooperative learning. Thus, students used plants and plant elements in tasks 1, 4, 8 and 12, and worked in groups of four students in tasks 4, 5, 6 and 8. Students worked individually in all evaluation tasks, and plants were only used in tasks A and B.

Figure 1

Concept Map of the Teaching Sequence Concerning the Plant Kingdom



Data Collection Instruments

Data were collected from the students during the evaluation tasks proposed at two milestones in the teaching sequence (before and after, milestones 1 (pre-test) and 2 (post-test), respectively) in order to gain an idea of students' performance in some of the contents considered to be important to the plant kingdom learning process (plant physiology and floral physiology) and the possible influence of cooperative learning and the use of real-life plants. This instrument was designed ad hoc on the basis of the curricular objectives (MECD, 2015).

Prior to the teaching sequence (milestone 1), two tasks (A and B) involving plants were proposed individually, one related to plant physiology and the other to flower physiology (see description in Table 2, tasks A and B). Students worked independently on a diagram for plant physiology and plant reproduction in milestone 1.

During the teaching sequence, the same activities were again carried out but, this time, in a cooperative manner in a group during tasks 4 and 8, respectively. These tasks were subsequently corrected in class. The cooperative learning method was addressed in the following way in those tasks:

(a) In task 4, related to plant physiology, each group chose two plants, thus allowing all the group the opportunity to observe plants.
(b) Each group then had to choose one of the angiosperm or gymnosperm plants observed, draw the plant and, using information given by the teacher, label different parts and write some information about them.

Table 2

Tasks and Objectives in the Two Different Milestones of the Intervention

Content	Sequence Content as Student Learning Outcomes: Students Will Be Able To	Milestone 1	Milestone 2
Plant Physiology	1.1 Know the different kinds of plants. 1.3 Understand the main characteristics of plant physiology (leaves, roots, stems). 2.4 Prepare schemes, explanatory drawings and diagrams about different plant parts. 3.1 Be sensitive about plants.	Task A. Each student should choose one plant from a group of different angiosperms, gymnosperms, mosses and ferns that the teacher brings to the classroom in pots or in pieces from the trees. Students have to observe, study and label them with the different parts (leaves, roots, stem), prepare a drawing and write a brief explanation of them (Figure 2, left).	Task C. Students were asked to draw a diagram of an angiosperm plant, label its parts and explain their characteristics (Figure 2, right)
Floral Physiology	1.2 Understand the vital function of reproduction in plants. 1.4 Know the different parts of angiosperm flowers and their functions. 2.4 Prepare schemes, explanatory drawing and diagrams about angiosperm flowers. 2.5. Perform a floral dissection. 3.1 Be sensitive about plants.	Task B. Students should do a flower dissection. They have to separate each part of the flower and stick them on a piece of paper to label them correctly. (Figure 3, left).	Task D. Students were asked to complete the names of all the parts of a flower in a scheme (Figure 3, right).

(c) In the session about flower physiology (task 8), after a brief explanation of angiosperm flowers, and with the support of a labelled diagram on the board, each group had to separate the different parts of an angiosperm flower, stick them on a piece of paper and label them correctly.

Finally, after the sequence (milestone 2), two individual tasks (C and D, Table 2) were proposed involving the same knowledge but without the use of plant elements and slightly different statements, in order to determine whether students were able to transfer their learning to another context.

Students were given 1 hour to perform the evaluation tasks proposed for each milestone and were not allowed to use classroom notes to resolve them. Figures 2 and 3 show some examples of the students' productions.

Figure 2

Students' Productions in Tasks A and C on Plant Physiology at Milestones 1 (left) and 2 (right)

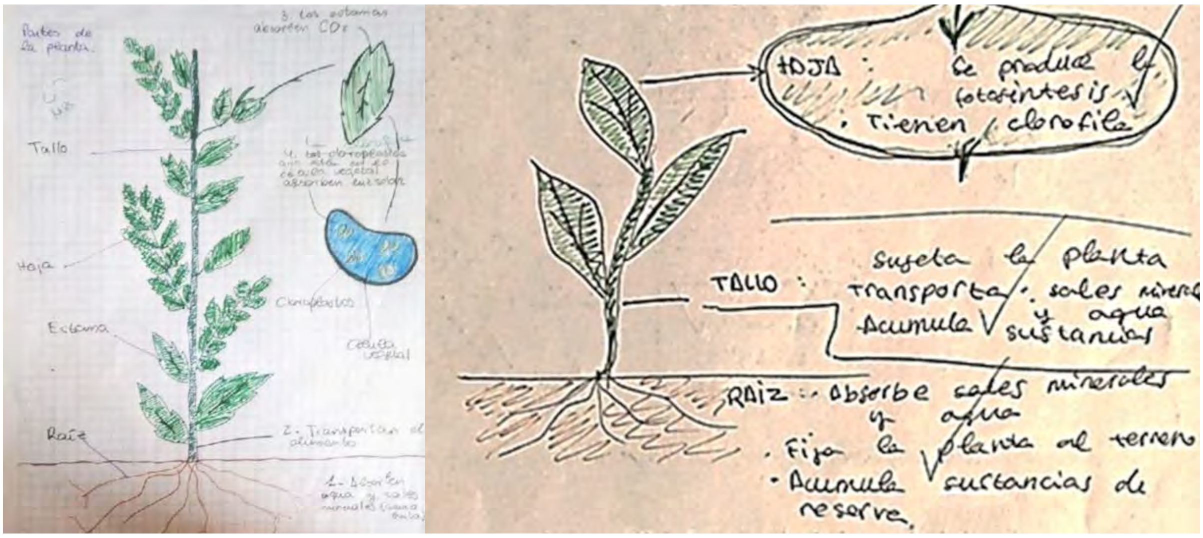
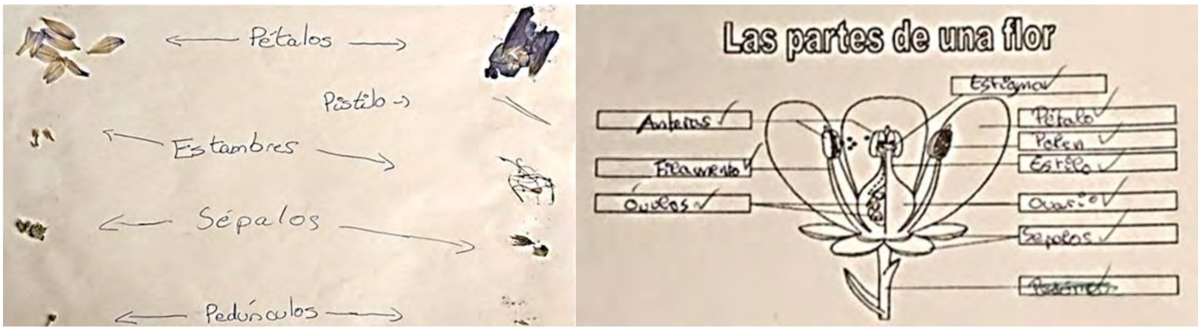


Figure 3

Students' Production in Tasks B and D on Floral Physiology at Milestones 1 (left) and 2 (right)



Data analysis

The results from tasks A, B, C and D were analysed by categorising the responses given into three levels of learning: informed, transitional and naïve.

The categories used during analysis of the plant physiology task were:

(a) Informed level: The student is able to identify all angiosperm plant parts and their functions.
(b) Transitional level: The student is able to identify some parts of the plant and/or some of its functions.
(c) Naïve level: The student is not able to identify the parts of the plant or their functions.

The categories used for floral physiology were:

(a) Informed level: The student knows and is able to identify all parts of the angiosperm flower.
(b) Transitional level: The student knows and is able to identify only some parts of the angiosperm flower.
(c) Naïve level: The student does not know and is not able to identify any part of the angiosperm flower.

The effectiveness of the cooperative learning task and the use of real-life plants were studied in two ways. Thus, an initial study analysed the evolution of the level of learning shown (informed, transitional or naïve) by all students at the two intervention milestones. A second analysis studied the evolution of each student's learning by comparing their level (informed, transitional or naïve) before and after the teaching sequence. It was found that some students improved their learning to some degree (naïve to transitional, naïve to informed), maintained their learning (naïve to naïve; transitional to transitional; or informed to informed) or became worse (transitional to naïve).

In addition, Fisher's exact test was used to verify the existence of significant differences between the two milestones using the statistical software package SPSS 21.0.

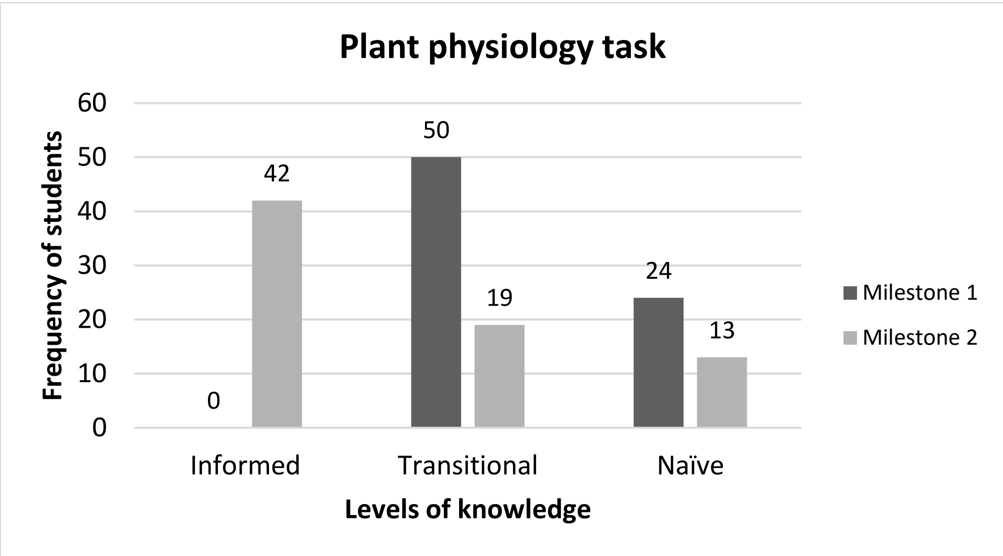
Findings

Plant Physiology

The results of the two milestones for the plant physiology task are shown in Figure 4. These results seem to indicate that the task carried out in cooperative learning with plant elements from the natural world produces a significant improvement in the learning of this topic. Thus, before the sequence, 100% of students had a transitional/naïve level of knowledge on this topic, while at the end of the sequence 56.7% (42/74) of them achieved an informed level.

Figure 4

Plant Physiology Results



The study of the evolution of the level of learning between the two milestones revealed advances in learning in most cases (Table 3). Thus, most students (37.8%) changed their levels of knowledge from transitional to informed, and 18.9% started with a naïve level and finished the sessions with an informed level. Similarly, 6.8% increased their level from naïve to transitional. It should be noted that only 10.8% of students worsened their learning, moving from transitional to naïve.

Table 3

Changes in Levels of knowledge between milestones 1 and 2 for plant and floral physiology tasks

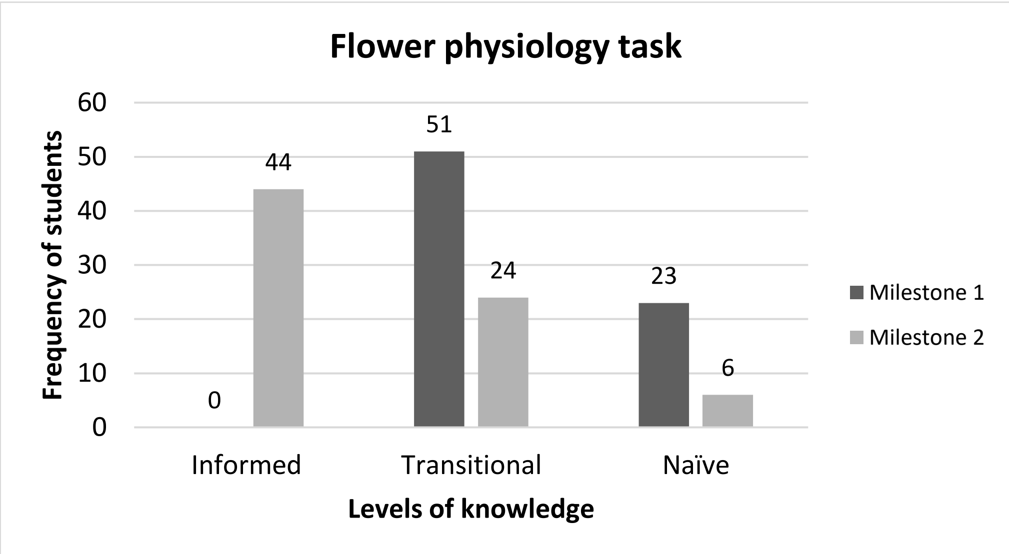
		Plant Physiology Task (N = 74)	Floral Physiology Task (N = 74)
Changes between levels of knowledge	Evolution of learning process	Students' percentages (%)	Students' percentages (%)
Naïve to naïve	Students keep their learning	6.8	5.4
Naïve to transitional	Students improve their learning	6.8	12.2
Naïve to informed	Students improve their learning	18.9	13.5
Transitional to naïve	Students' learning worsens	10.8	2.7
Transitional to transitional	Students keep their learning	18.9	20.3
Transitional to informed	Students improve their learning	37.8	44.6
Informed to naïve	Students' learning worsens	0.0	0.0
Informed to transitional	Students' learning worsens	0.0	0.0
Informed to informed	Students keep their learning	0.0	1.3

Flower Physiology

In a similar way, students improved remarkably in their learning in the area of floral physiology (Figure 5) since 100% of participants had a transitional/naïve level of knowledge at milestone 1, whereas 59.4% (44/74) reached an informed level at the end of the intervention.

Figure 5

Floral Physiology Results



As can be seen from Table 3, 44.6% of students changed their level of learning from transitional to informed, 13.5% started with a naïve level and finished the teaching sequence with an informed level, and 12.2% of participants increased their level from naïve to transitional. Only 2.7% of students suffered a setback in their learning, moving from a transitional to a naïve level.

Global results

Fisher's exact test showed statistically significant differences between the two milestones (χ^2 = 59.2, p = 0.00, for the plant physiology task; χ^2 = 63.69, p = 0.00, for the flower physiology task) in favour of the second milestone. These results indicate the effectiveness of the tasks proposed (cooperative learning with elements of the plant world), which allowed students to successfully solve a similar task individually.

Discussion and Conclusion

A first aspect to address with regard to students' level of engagement with the topic is that both cooperative group-learning tasks (plant physiology and flower dissection) with plant elements allowed them to better understand the different aspects and parts of plants and flowers. This allows them to recognize the different elements in both structures and to design or understand a diagram with both structures, thereby confirming the starting hypothesis. These results are in line with previous studies (Chatila, Husseiny, 2017; Rabgay, 2018), which found that cooperative learning increases students' performance and their attitude towards biology, thereby improving their level of interest, understanding, and satisfaction, and their perception of biology as a less difficult subject.

A second important aspect to consider relates to the capacity of students to work in groups in a productive manner, being respectful and discussing with each other in order to find the best way to perform and complete the different diagrams to reach a common outcome that all of them agree with. In this regard, cooperative learning contributed to empowering students' scientific knowledge by favouring reasoned and consensual decision-making when performing the tasks after taking into consideration the different viewpoints of each student. This also helps to enhance critical thinking of biological concepts (Lord, 2001).

The teaching sequence presented can be considered as a successful experience. However, it is not free from drawbacks if other teachers wish to put it into practice, since it requires some materials, such as plant elements, that are not usually found in schools. Collaborations between schools, universities and botanical gardens (Zhai, Dillon, 2014) are a good way to provide interesting cooperative learning activities with plant elements in high schools.

In summary, these active learning group activities have allowed students to learn: (1) The different parts of a plant and the implications of each part, (2) the different parts of a flower and the position of them in the flower, (3) to work in groups and to respect each other in order to finally be able to achieve a common aim. Moreover, these tasks allow students to learn about plant and floral physiology, as they are opening their minds to a collaborative way of working with people around them that they may never have experienced previously, while giving them the opportunity to develop their social skills (Lord, 2001) and perhaps even reduce their levels of anxiety (Oludipe, Awokoy, 2010).

However, as seen from the results, it is also possible that some students do not benefit from this learning method (Shimazoe, Aldrich, 2010). Those students whose level does not improve or, even, decreases could have cognitive problems or problems socialising. Future research may include a prior study to classify students depending on their learning levels, which would allow heterogeneous groups with students from all the different cognitive levels to be organised (Felder, Brent, 2007). Moreover, students with different needs should have specific differentiated tasks in order to give them all the tools they need to allow their maximum effort to be reflected in their results. The motivation for students should be promoted via the use of games, quizzes or any activities that could give them an extra reward when learning about plants in order to increase the interest and to make the topic even more attractive.

In conclusion, we can state that a combined method involving cooperative learning and the use of plant elements is an effective methodology for the development and understanding of biology in high school students, as suggested by previous studies that used cooperative learning (Altun, 2015; Day, Bryce, 2013; Slavin, 1995; Tran, 2014; Zakaria, Iksan, 2007) or contact with the natural environment separately (Dadvand et al., 2015; Jose et al., 2019; Wells, Rollings, 2012).

Further studies are required to further investigate students' level of satisfaction and their development of all skills in this combined methodology within secondary school science education lessons in order to complete this type of analysis.

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