EVALUATION OF TWO MODELS OF TEACHING AS ORIENTED-RESEARCH AS A TOOL TO OVERCOME ALTERNATIVE IDEAS ABOUT SEASONS

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Abstract

The origins of scientific misconceptions are tied to a varied set of personal experiences, which include observation of the immediate environment, culture, language and previous instruction at school. The usual teaching methodologies do not take into account the existence of these ideas, underestimating the influence of these misconceptions may have on learning. In all education levels, students already have a constituted empirical knowledge and hence, those obstacles accumulated in their daily life have to be taken into account in order to promote meaningful science learning. In the Spanish Primary and Secondary Education curriculum, the topic on the Seasons and the Sun/Earth Model is included; however, future Primary Education teachers, who are supposed to have learnt these topics during their secondary education and who also will teach this subject in the future, present scientific misconceptions about these. In this work, we present some misconceptions related to one of these topics (cycles and symmetries of Sun's movement as observed from the Earth) and we also assess to what extent these alternative ideas (or misconceptions) can be overcome during the training period of pre-service primary teachers at the University, using an oriented-research (i.e. inquiry-based) teaching approach. The study was carried out at two universities with a total of 280 prospective teachers at University A and 73 prospective teachers at University B. University A carried out an oriented-research teaching/learning methodology of 40 hours duration and 42 activities in total, and University B conducted an inquiry-based teaching sequence consisting of 11 activities and a total duration of 8 hours, addressing the same research questions. Initial and final knowledge level attained by students was assessed using a pre-test/post-test questionnaire with questions about the apparent movement of the Sun, written in everyday life words. We used chi-square test to compare the percentage of students of the two universities that responded correctly to these questions. Results obtained showed that the initial level of knowledge (i.e. pre-test) was very low or practically zero (in 10 of the 13 items in the questionnaire the percentage of correct answers was equal to or less than 5%), and almost any difference between students of the two universities was found. On the contrary, results of the post-test showed that the level of knowledge reached by the students from University A was significantly higher compared to that attained by students from University B (only in three of the 13 items we did not find significant differences between universities). Although students of University B improved in the post-test results, we found that the level of knowledge reached by the students of university A were significantly higher. Post-test results revealed that a significant higher percentage of students of University B had not overcome the misconceptions about seasons and Sun cycles and symmetries, which they had from the beginning. This result leads us to think that to learn any science idea in depth, which is known to be very important to overcome spontaneous ideas, the time that dedicate to it is of paramount importance. These results support that the study of science subjects in depth should be prioritized, rather than addressing a greater number of subjects in a more superficial way. Real learning takes time.

Keywords: Astronomy, misconceptions, pre-service teachers.

1 INTRODUCTION

Scientific misconceptions in students have their origin in both life personal experiences (e.g. observation of the immediate environment, culture and language expressions) and previous instruction at school [1]. Usual teaching methodologies do not take into account the existence of these alternative ideas, underestimating the influence that misconceptions may have on learning. That is why, many researchers (e.g. [2], [3], [4]) currently support the idea that science learning and teaching should be developed as a process of knowledge (re)construction based on scientific practices, adapted to the

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classroom reality. Therefore, in all education levels, teachers should always take into account students' previous empirical knowledge, as a starting point, in order to promote meaningful science learning.

Further step to base science teaching in the development of an immersion process in scientific practices, is to organize themes and courses with a problematized structure. That is to create an oriented-research (i.e. inquiry-based) teaching approach [5]. Therefore, in a classroom environment where teaching is organized to propose and advance in problems of interest, learning occurs because of a guided research process. In this model, learning is conceived as a process of evolution and conceptual and epistemological change, and teaching as the implementation of the plan of activities to achieve that change (e.g. [6], [7]).

The topic of the Seasons and the Sun/Earth Model is included in the science core ideas established by the National Research Council (USA) [2]. It is also included in the Spanish Primary and Secondary Education curriculums ([8], [9]) and, since it has an important empirical part (as some data can be recorded as observer from the Earth to develop a Sun/Earth model) it gives enough opportunities to be taught using an inquiry-based problematized structure. Regarding this theme, we have noticed that future Primary Education teachers, who are supposed to have learnt about it during their Secondary Education and who will have to teach this subject in the future, present serious scientific misconceptions on it.

Hence, in this work we analyse some misconceptions related to one of these topics (cycles and symmetries of Sun's movement as observed from the Earth). Our goal is to detect these initial alternative ideas and to assess to what extent these misconceptions can be overcome during the university training period of pre-service primary teachers, by using an oriented-research teaching approach. For this purpose, we compare two universities (A and B) that follow different methodologies. In spite of those methodologies being both based on scientific inquiry, first one follows an oriented-research teaching/learning methodology, while University B conducts an inquiry-based teaching sequence of activities, addressing the same research problems.

Two questions guide our work: Does oriented-research teaching approach provide better results when overcoming misconceptions than other methodologies? Does time spent in teaching have a significant influence in students' learning? Our hypothesis is that a problematized organization of the subject has a very positive effect on students' learning and misconceptions' overcoming.

2 METHODOLOGY

Initial and final level of knowledge attained by students has been assessed using a pre-test/post-test questionnaire. It comprises thirteen questions about the apparent movement of the Sun as observed from the Earth, written in colloquial language. We used chi-square test in a contingency table to compare the percentage of students of the two universities that answered correctly to these questions.

The questionnaire was developed taking a previous one as reference ([5], [10]), which was designed to know the alternative ideas on the subject of the movements of the Sun and the Earth. The content validity of the questionnaire was confirmed by the judgment of a panel of eight experts in the subject, previous to its use in the present study.

2.1 Data collection and samples characteristics

The study has been carried out at two Spanish universities (A and B). At University A, the test was conducted on 280 prospective teachers; whereas, at University B, were just 73 prospective teachers who participated in our study. First university carries out an oriented-research teaching/learning methodology of 40 hours duration and 42 activities in total. Alternatively, University B conducts an inquiry-based teaching sequence consisting of 11 activities and a total duration of 8 hours, addressing the same research questions. Both methodologies are based on scientific inquiry, but that conducted at the university A is more structured that than in university B, starting with a problem to be solved and the rest of the activities are focused to respond to that question; students are asked to provide hypothesis, address how to test their hypothesis, get data and obtain conclusions.

2.2 Pre-test and post-test questionnaire

The questions that compose our questionnaire are the following:

1 Why could it be interesting for people to know how the Sun moves during a day, and throughout a year, in its locality and in other parts of the world?

2 Imagine that you have neither a compass nor a GPS. Express how could you accurately determine: The North/South direction, the East/West direction.

3 If you have neither a watch nor other "artificial" tools, indicate how to know when it is noon (be as accurate as you can).

4 Somebody affirms that the position of the Sun at noon, measured with a compass, is 180º. Express in your own words and with drawings, what that means.

5 We want to measure the sun elevation above the horizon at a day moment, but we cannot directly look at it, because it is harmful to the eyes. Indicate how could you determine the "height" of the Sun above the horizon.

6 How can somebody know, with the Sun, whether he is in “place A” or in Buenos Aires?

7 Somebody affirms that, in “place A”, there are days in the year in which the Sun rises between the East and the South. In relation to this statement, we can say (qualifies each sentence as "True" (T), "False" (F) or "I do not know"):

- That is true and in those days the Sun will set between the West and the South
- That is true and those days occur in summer
- It is not true, the place where the Sun rises is always the same (the East)
- It is true and there are other days in the year in which it rises between the East and the North
- (Write a true statement that expresses what you think about this issue):

8 Express how can we know with the Sun: when does a season begin and when it ends?; what season are we in (put an example for one)?

9 Concerning the day length.

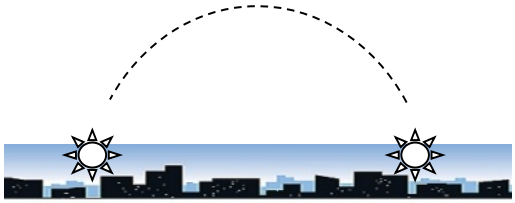
- Someone states that daytime duration of 15th of May is longer (i.e., the sun stays longer above the horizon) than 15th of August. Express whether you agree with this statement and why.
- At what times of the year are the longest days? And the shortest?
- Give the name of two months in which day 30 lasts less than day 1
- Give the name of two months in which day 30 lasts longer than day 1

10 Comment the following sentence: "Although day length and Sun elevation at noon change, sunrise and sunset always happen at the same places".

11 Comment the following sentence: "There are places on our planet where, at some periods of the year, Sun elevation at noon is almost 90° (above the head) and, at another periods of the year, it is almost 0° (almost on the ground)".

12 We have measured daytime duration on May 30. How long will it take until there is a day that lasts the same?

13 As you know, Sunpath (the trajectory we see above the horizon) is not always the same. Below, there is the drawing somebody has made of the Sunpath in a winter day. If you were looking from the same point, how would the trajectory on a summer day be? Make a drawing of it.



(horizon line)

Sun trajectory on a winter day

(horizon line)

Sun trajectory on a summer day

3 RESULTS

In Table 1, we show the percentages of students who have given correct answers to each question, for both universities and hence, these responses do not show misconceptions.

Table 1. *Pre-test/post-test comparison between students from University A and B.*

Questions	Pre-test				Post-test			
	A (293)	B (73)	chi-square G.L.=1	*p*	A (280)	B (73)	chi-square G.L.=1	*p*
	Right answer (%)	Right answer (%)			Right answer (%)	Right answer (%)		
2	1	0	0,032	0,858	38	22	6,773	0,009
3	5	1	1,381	0,240	75	34	42,284	0,000
4	1	1	0,029	0,864	67	40	18,720	0,000
5	1	1	0,029	0,864	64	40	12,824	0,000
6	0	0	0,029	0,864	57	15	40,363	0,000
7	5	0	2,444	0,118	86	78	2,810	0,094
8	0	0	0,029	0,864	35	52	7,111	0,008
9	5	5	0,029	0,864	40	36	0,395	0,530
10	13	1	6,797	0,009	82	58	19,832	0,000
11	0	0	-	-	27	7	12,959	0,000
12	4	0	2,188	0,139	63	23	36,585	0,000
13	25	34	2,807	0,094	70	73	0,141	0,707

Results obtained for the pre-test questionnaire show that only statistically significant differences between A and B students were found in item 10; for the rest of the items, differences were not significant ($p > 0.05$). Group A got slightly better results in most of the questions (unless 13), although the level of knowledge was very poor in both cases. Just item 13 provides a percentage of correct answers close to 30%.

On the contrary, results of the post-test show that the level of knowledge reached by the students from University A is significantly higher compared to that attained by students from University B. Only in items 7, 9 and 13 we did not find significant differences between the two universities. Similarly, in question 8, group B obtained better results.

Although students of University B improved in the post-test results, we found that the level of knowledge reached by students of University A was significantly higher. Post-test results reveal that a significantly higher percentage of prospective teachers from university B had not overcome their initial misconceptions about seasons and Sun cycles and symmetries.

We link these results to two main related causes: the used methodology and the number of hours dedicated to instruction (40 versus 8). Regarding the methodology, both groups use inquiry-based programs, but at University B not all the characteristics of a problematized structure, i.e. oriented-research teaching, are present: there is lack of an index or working plan, the planned activities are more directed and the hypotheses formulation, as well as the empirical experimentation, are more limited. At University B, despite working with a program of activities (somehow problematized), the limitation of time and the few questions proposed to students, force professors to introduce concepts that should arise in the development of the subject to solve the problems.

Thus, for students to achieve an adequate level of success in a subject, the time we spend on it is very important. Subsequently, if we do not dedicate enough time, it is going to be impossible to develop a proper oriented-research methodology. If only little time is devoted to the teaching/learning process, only a superficial knowledge can be achieved, which could be hardly used outside of the contexts where it has been explained (e.g. outside the school context, to deal with new problematic situations). For this reason, if we want students to appropriate of scientific ideas that substitute their previous spontaneous thoughts, it will be indispensable to dedicate the necessary time for the development of the subjects in depth.

4 CONCLUSIONS

Results of this study support our hypothesis that a problematized teaching of the subject has a very positive effect on students' learning and misconceptions overcoming. Nevertheless, this methodology needs time to be properly used. Otherwise, students' learning would not be truly significant and functional to be applied in the real life. For that reason, the study of science subjects in depth should be prioritized, rather than addressing a greater number of topics in a more superficial way. In this learning context, students have the opportunity and the time to express their own ideas and hypothesis, design experiments to test them and to obtain self-results that will be set in common with the class. This sequence of activities should be developed working in small groups, which are guided and oriented by the teacher, and all this, just because real learning takes time.

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