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A survey on Roma Tre University students' physics initial knowledge

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Summary. — In this work, we show and analyze the results of a survey that investigated the initial physics knowledge at the entrance of some scientific degree courses of Roma Tre University. In this way, we reflect on the basic knowledge possessed by students upon leaving high school, and on their scientific literacy.

1. – Introduction

Students do not enter a course of study without any idea about physics: from a very young age, in fact, they possess several ideas and beliefs about the physical phenomena that surround them. When alternatives to scientific reasoning, these ideas are called *alternative conceptions*. These conceptions, although may not represent a coherent whole, seem very resistant, and can therefore greatly affect what a student learns in a course [1]. For this reason, bringing out these conceptions at all school levels is particularly important.

At Roma Tre University, we focused on the alternative conceptions present in students just enrolled in different scientific degree courses. Specifically, we carried out a survey aimed at investigating their physics knowledge before they attended a physics course: in this way, we could analyze the knowledge possessed upon leaving secondary school by those students who are interested in scientific fields, at least to some extent. Our aim was also to highlight the possible presence of alternative conceptions in their answers, and, if possible, quantify their diffusion.

2. – Survey and results

Our survey involved 492 students just enrolled to 8 different scientific degree courses of Roma Tre University: Physics (46 students), Mathematics (31 students), Biology (73), Geology (25), Computer Engineering (106), Civil Engineering (27), Electronics Engineering (135) and Environmental Protection and Sustainability Science (hereafter, EPSS, 49). At the time of the survey, none of the students had yet followed the physics course provided for by their study plan.

In order to have the maximum possible participation, we proposed our test during the lessons of the most popular core courses. This meant that the test could not last longer than 20–30 minutes at most, since we were taking time away from the lesson.

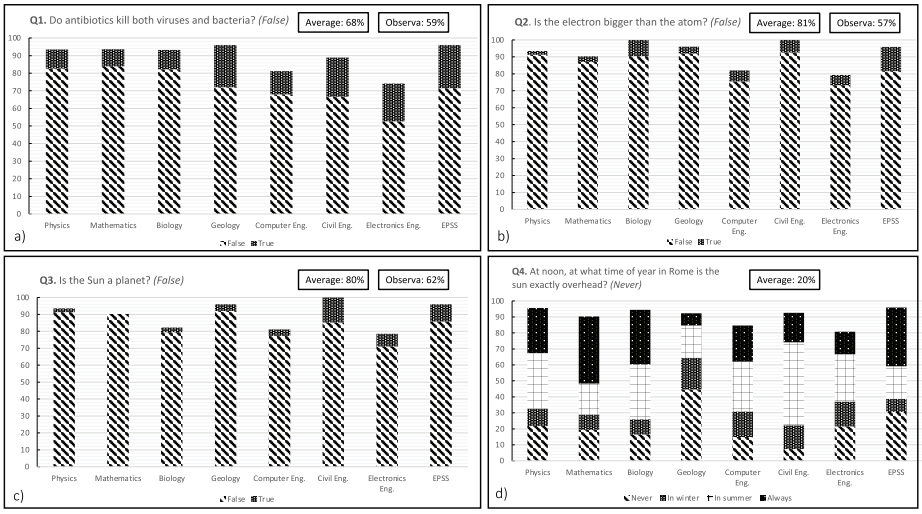

Fig. 1. – The answers we received to our survey according to the degree course. Correct answers are indicated in brackets after the questions. The "Average" square shows the average value among all students, the "Observa" square indicates the average value reported in [3]. An overall percentage other than 100% indicates that not all students who accessed the quiz answered that question.

We therefore chose a very fast and engaging test mode using *Kahoot!*([1]), a tool that allows creating multiple-choice quizzes, and which guarantees rapid play times and keep participants' attention high [2]. Moreover, *Kahoot!* provides a live ranking([2]). These elements ensured that participants were engaged during the whole quiz, and willing to answer all the questions as much as correctly as possible. Given the conditions described above, we decided to propose to our students 8 multiple-choice questions, each of which had to be answered in a short time (30 or 60 seconds). Therefore, our survey does not analyze the reasoning behind the answers given by the students, yet investigates instinctive answers given by the students involved.

The first four questions, proposed at the beginning of the quiz, were meant to break the ice and make students understand how the game worked. For this reason, they did not provide any score. Three of these questions (Q1, Q2 and Q3) have been chosen from the Observa's "Annuario Scienza Tecnologia e Società" [3], which is intended to evaluate the scientific literacy of Italians over the years; one question (Q4) came instead from previous studies investigating alternative conceptions regarding the Sun/Earth relationship [4,5]. These questions are displayed in fig. 1; their response time was 30 seconds. To the first question (Q1, fig. 1(a)) 68% of total students answered correctly; to the second (Q2, fig. 1(b)), 81%; to the third (Q3, fig. 1(c)), 80%. As far as the last question (Q4, fig. 1(d)) is concerned, the percentage of correct answers dropped to only 20%([3]).

The other four questions of the quiz were selected among those extensively studied in the literature [6] that have been built to bring out alternative reasoning schemes.

([1]) *Kahoot!* is a game-based learning platform: `kahoot.com`
([2]) In some cases, we pushed the competition even further by giving small prizes to the winners.
([3]) It is worth noting that for this question, students of EPSS were favored as they had just attended a course about Earth Sciences, which addresses these topics.

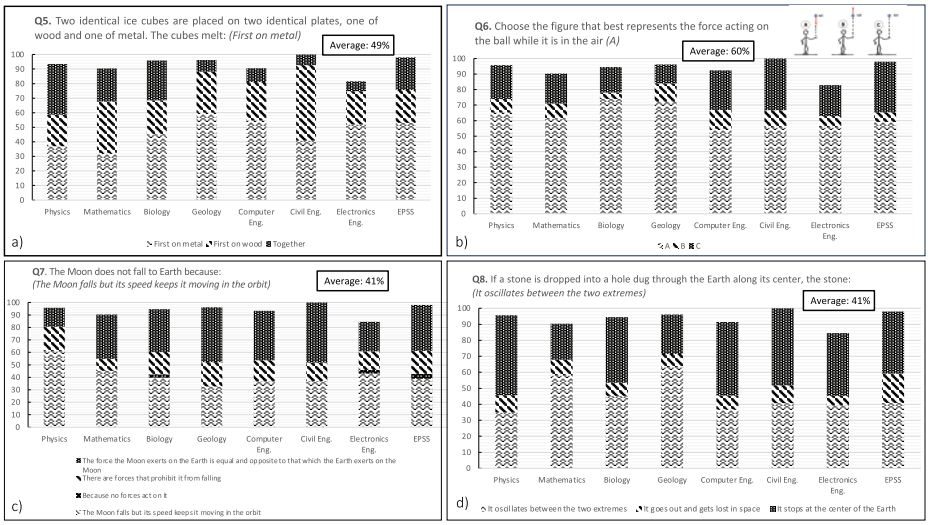

Fig. 2. – The answers we received to our survey according to the degree course. Correct answers are indicated in brackets after the relevant questions. The "Average" square shows the average value among all students. An overall percentage other than 100% indicates that not all students who accessed the quiz answered that question.

We focused on three topics, all addressed by students in their studies: Thermology (1 question, Q5), Mechanics (1 question, Q6), Gravity (2 questions, Q7 and Q8). These questions, shown in fig. 2, could be answered in 60 seconds. To the first question of this part, Q5, only 49% of all students gave the correct answer, with strong variations between the different degree courses (fig. 2(a)). In particular, the majority of students just enrolled in the Physics degree course did not give the correct answer. To the second question, (Q6) the percentage of positive responses was, on average, 60% (fig. 2(b)). The third question was answered correctly by 41% of students from all degree courses (Q7, fig. 2(c)). As regards the forth question (Q8), only 41% of students chose the correct alternative (fig. 2(d)).

3. – Discussion and conclusion

In our survey, which involved 492 students just enrolled to 8 different scientific degree courses at Roma Tre University (Physics, Mathematics, Biology, Geology, Computer Eng., Civil Eng., Electronics Eng. and Environmental Protection and Sustainability Science), we found a significant presence of alternative interpretative schemes regarding physics. Although the impossibility to justify the answers and the rapid response times that characterize our questionnaire do not allow for an in-depth analysis comparable with other previous studies [6], from our data we can however obtain important indications on the basic knowledge of the students involved, and on what is really part of their cultural background after attending high school.

As for thermology (Q5), about half of the overall students gave the correct answer, but with strong variations from one degree course to another: for example, only about 35% of students just enrolled in the physics degree course gave the correct answer. These data therefore tell us that mastery of the concepts of temperature, specific heat or conductivity is not part of the cultural background of our students when they leave high school. As far as mechanics is concerned (Q6), the situation seems to be improving, since the majority of

students (60%) gave the correct answer. Nevertheless, a considerable number of students still show confusion, for example between the concepts of force and speed. As regards gravity (Q7 and Q8), the situation is even worse, since the percentage of correct answers on the entire population examined is about 41%. In this case, alternative interpretative schemes are predominant for the majority of degree courses, indicating a widespread lack of true understanding of these phenomena. As for thermology (Q5), about half of the overall students gave the correct answer, but with strong variations from one degree course to another: for example, only about 35% of students just enrolled in the physics degree course gave the correct answer. These data therefore tell us that mastery of the concepts of temperature, specific heat or conductivity is not part of the cultural background of our students when they leave high school. As concerns mechanics (Q6), the situation seems to be improving, since the majority of students (60%) gave the correct answer. Nevertheless, a considerable number of students still show confusion, for example between the concepts of force and speed. As regards gravity (Q7 and Q8), the situation is even worse, since the percentage of correct answers on the entire population examined is about 41%. In this case, alternative interpretative schemes are predominant for the majority of degree courses, indicating a widespread lack of true understanding of these phenomena.

Also the initial questions of our survey, taken from the "Annuario Scienza Tecnologia e Società" [3] (Q1, Q2 and Q3), give us a hint about science literacy of our students. If we compare the answers to these questions with those given by the Italian general public [3], in fact, we can confidently state that young people enter a scientific degree course with a higher degree of basic scientific literacy. A separate discussion should instead be made on topics related to the relationship between the Sun and the Earth, which do not seem to be part of the cultural background of high school students at all (Q4).

The analysis presented in this work is only preliminary. Nonetheless, we believe that our survey represents a valuable tool for the whole educational community as it can help focus on what it means to have a basic scientific literacy today, especially in physics, and what are the issues on which we must concentrate and discuss in the future. In the near future, we plan to carry out a more detailed analysis of our data, and replicate the survey over time. Moreover, we would like to repeat the survey in Master's degree courses, to understand if we can pass these concepts on during three-year degree courses. Furthermore, the survey could be extended to other Universities.

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