Abstract. The low percentage of students (43% of applicants) that passed the entrance exams for the bioengineering career at the National University of San Juan in 2007, plus the historical situation of desertion in first year (about 50%), motivated the application of a diagnostic test to prospective students of this career. The aim of this test was to obtain information about the competences acquired by students to solve problems in different contexts using basic mathematical tools, reading comprehension skills to understand texts, graphs and tables. Although this test was sat by the entire population of applicants of the current school year, only the results belonging to bioengineering students are the ones presented for the purpose of this work. However, students of other disciplines of the school of engineering also have similar problems. From the analysis of the answers to the different items, it can be observed that there are serious difficulties in the development of basic capacities to successfully take the courses of this career.

Key words — University, Applicants, Pre-university Level, Competencies.

1. Introduction

Students’ failure to enter higher education coupled with the non-permanence in the selected career is a problem shared by different national and international universities [1], situation to which the school of engineering is not an exception. For this reason, it was decided to give applicants a diagnostic test (454 students). The results obtained from bioengineering applicants (25 students) are shown in this work. This activity was carried out with the institutional support of the school of engineering within the framework of the interschool research project “Strategies for the learning of Basic Sciences based on the model for competencies”.

Current educational tendencies state that the future citizen requires new types of learning, and that education must focus on the development of basic attitudes for life and capacities to solve problems in diverse contexts. Students’ capacity to detect which variables are important for their learning and how to have the control of it has to do with self-regulated learning [2]. Taking into account that mathematics as well as knowledge of the language become fundamental tools for the significant learning of sciences, and of physics in particular, it is in this group of teachers that the
following queries arouse: Are applicants capable of solving problems in an everyday context? How can we thus determine the level of competence acquired by them?

In order to give an answer to these questions, a diagnostic test was given to find out not only the level of knowledge of specific contents, but also the applicants’ capacity to use mathematical knowledge and skills to tackle troublesome situations of everyday life. It is important to point out that it is the first time that a test of these characteristics is given to applicants; that is why, the results cannot be compared with those of previous years. In short, we aim at finding out how students apply skills and attitudes that allow “thinking mathematically, understanding a mathematical argumentation, and expressing and communicating in mathematical language, by means of making use of appropriate support tools, and integrating the knowledge of mathematics with other types of knowledge to give a better answer to everyday situations of different levels of complexity” [3]. In spite of the fact that this kind of test does not allow us to state a deterministic type of relationship between the answers given and the capacities brought into play to find them, it is feasible to get traces of this relationship from the analysis of these answers.

2. Methodology

2.1. Instrument

Basically, the material used for the diagnostic test was taken from tests released by the Programme for International Student Assessment (PISA) [4] [5]. This programme carries out international studies to evaluate, among other things, knowledge and skills of 15-year-old students. This programme is promoted by the Organization for Economic Co-operation and Development (OECD) [6]. The aim of PISA/OECD assessment is to establish indicators that show a society’s development when considering the way the educational systems prepare 15-year-old students to play an active role in society [7]. The tests have a particular format in which, from a given text, various related questions are made with the purpose of activating skills and proceedings. The reason for choosing this material is that the contextualized situations proposed make the task suggested meaningful. It should be mentioned that some changes have been introduced to the original tests so as to adjust them to the group of students. A 26% of the items were added (at National University of San Juan), or its wording adapted to the local context; for example, change of currency and name of subjects in accordance to the ones taken in our school.

2.2. Characteristics of the diagnostic instrument

The instrument used was a paper-and-pencil test with five problems representing a variety of situations, such as: basic mathematical concepts; decision making; interpretation of instructions, tables and graphs; and inferring. To solve them correctly it is needed, among other things, to understand information given in colloquial language and translate it into an algebraic register and vice versa, interpret and connect the same information presented in different ways, reflect on the relationship between an algebraic formula and implicit data, make decisions subject to determining factors. The stipulated time to make the whole test was an hour, and the use of calculators was allowed.

Students’ personal data was also requested, and it included: name of secondary school, field of concentration, weekly and daily number of hours devoted to study, study preference (in groups or individually), reason for choosing the career, and future expectations. From this data, only the items related to reason for career choice and future expectations were the ones taken into consideration.

The results of the test and the tables with the students’ answers, corresponding to each item, they are stated in percentages, are shown in section 3. Two figures are also presented: marks of bioengineering applicants (Figure 4), and comparison of results with other careers of the school (Figure 5).
2.3. The Test

The content of the test used is shown below:

**Exercise 1: Lichens**

As a consequence of the global warming of the planet, the ice of some glaciers is melting. Twelve years after the ice disappears, tiny plants called lichens start to grow on rocks. Lichens grow in a circle form.

The relationship between this circle and the age of the lichen can be stated approximately by using the formula: \( d = 7.0\sqrt{t-12} \); being \( d \) the diameter of the lichen in millimetres, and \( t \) the number of years passed since the disappearance of the ice.

a) Calculate the diameter that a lichen will have 16 years after the disappearance of the ice.

b) What can you say about lichens 8 years after the disappearance of the ice from the place?

c) Ana measured the diameter of a lichen and it was 0.035. How long has passed since the ice disappeared from that place?

D) If the diameter Ana measured doubled the previous one, how long has passed since the ice disappeared from that place?

**Exercise 2: Young people are becoming taller**

Since 1980 the mean height of girls has increased 23 mm, reaching 170.6 cm.

![Figure 1. The mean height of boys and girls from The Netherlands in 1998 is shown on the graph.](image)

a) What was the mean height of 20-year-old girls in 1980?

b) During which period/s of their lives are girls taller than boys of their same age?

c) During which period/s of their lives are boys taller than girls of their same age?

d) At what average age/s have girls and boys got the same height?

e) Explain how the growing rate of girls’ mean height decreases at the age of 12 onwards is reflected on the graph.

**Exercise 3: Postal rates**

| Table 1. Postal rates of correspondence depend on its mass (rounded to the nearest gram value) |
|---|---|
| Mass (g) | Rates ($) |
| Up to 20 | 0.45 |
| 21-50 | 0.70 |
| 51-100 | 1.00 |
| 101-200 | 1.75 |
a) Which graph (Figure 2) is the best representation of the postal rates?

b) John wants to send a friend two letters of 40g and 80g respectively. According to the rates, decide if it is cheaper to send both letters together or separately. Show your calculations for both cases and present a conclusion.

Exercise 4: The lighthouse
Lighthouses are towers with powerful flashing lights on their top. Lighthouses guide ships during the night, when they sail near the shore. A lighthouse sends off flashes of light according to a fixed regular sequence. Each lighthouse has its own sequence.

After some time the sequence is repeated. A sequence period refers to the time a complete cycle lasts before it starts to repeat. Once the sequence period is found out, it is very easy to broaden the diagram for the seconds, minutes, or even hours that follow.

a) How long does the sequence period of this lighthouse last?
A. 2 s  C. 5 s
B. 3 s  D. 12 s

b) In how many seconds does this lighthouse send off flashes of light in one minute?
A. 4 s  C. 20 s
B. 12 s  D. 24 s
Exercise 5: Career programming

An institute of higher education offers the following 12 courses for a 3-year career in which the duration of each course is one year:

| Course Code | Course Name |
|-------------|-------------|
| 1           | C1 Calculus I |
| 2           | C2 Calculus II |
| 3           | F1 Physics I  |
| 4           | F2 Physics II |
| 5           | Q1 Chemistry I |
| 6           | Q2 Chemistry II |
| 7           | Q3 Chemistry III |
| 8           | E1 Electronics I |
| 9           | E2 Electronics II |
| 10          | E3 Electronics III |
| 11          | I1 Computing I |
| 12          | I2 Computing II |

Each student will take 4 courses a year so as to pass 12 courses in 3 years.

A student is allowed to take a course of a higher level only if in the previous year s/he passed the same subject of the lower levels. For instance, Chemistry III can be taken only after having passed Chemistry I and Chemistry II. In addition, physics I can be elected only after passing Calculus I, and physics II can be elected after passing Calculus II.

Fill in the following table with the courses in which a student should be registered each year. Write the codes of each course in the table.

Table 3. The courses in which a student should be registered each year

| Course 1 | Course 2 | Course 3 | Course 3 |
|----------|----------|----------|----------|
|          |          |          |          |

3. Results

Tables I through V show the percentages of the answers of the corresponding tasks graded as good (G), barely passed (BP), bad (B), and does not answer (NA). The answers were analyzed by taking into account the application of skills and attitudes that allow logic understanding in different contexts.

Table 1. Percentage of answers to exercise 1: Lichens

|   | 1a | 1b | 1c | 1d |
|---|----|----|----|----|
| G | 41 | 38 | 31 | 22 |
| BP| 38 | 16 | 34 | 25 |
| B | 22 | 29 | 34 | 53 |
| NA| 0  | 19 | 0  | 3  |
Table II. Percentage of answers to exercise 2: Young people are becoming taller.

|     | 2a | 2b | 2c | 2d | 2e |
|-----|----|----|----|----|----|
| G   | 28 | 72 | 63 | 69 | 22 |
| BP  | 41 | 0  | 22 | 16 | 0  |
| B   | 25 | 25 | 13 | 13 | 41 |
| NA  | 6  | 3  | 3  | 3  | 38 |

Table III. Percentage of answers to exercise 3: Postal rates.

|     | 3a |     | 3b |     |
|-----|----|-----|----|-----|
| A   | 9  | B   | 27 | 60  |
| B   | 2  | C   | 2  | 65  |
| NA  | 65 | G   | 17 | 13  |
| BP  | 4  | B   | NA | 4   |

Table IV. Percentage of answers to exercise 4. THE LIGHTHOUSE.

|     | 4a |     | 4b |     |
|-----|----|-----|----|-----|
| G   | 57 | BP  | 0  | 31  |
| B   | 12 | NA  | 24 | 32  |
| G   | 59 | BP  | 29 | 15  |
| B   | NA | NA  | NA | NA  |

Table V. Percentage of answers to exercise 5: Career programming

|     |     |
|-----|-----|
| G   | 34  |
| BP  | 3   |
| B   | 59  |
| NA  | 4   |

Figure 4 shows the marks obtained by bioengineering applicants in the diagnostic test in 2007. These marks are categorized according to the criterion normally used for mid-term tests of first-year physics I of this career. This criterion establishes that students pass a course without having to sit for a final exam when they get 70 or more points (>69) ["promocionalidad"]; they become students in good standing when they get between 40 and 69 points (>39), and have to sit for a final exam ["regularización"]; and when they get less than 40 points (<40), they have to sit for a final exam as external students, or do that course again ["pérdida de regularidad"].
Figure 5 shows a comparison of the marks obtained by students of different careers of the school that took the diagnostic test. The criterion for the categorization was the same used for Figure 1.

![Figure 5. Comparative marks of different careers.](image)

4. Conclusions
In general terms, diagnostic tests are used to find out about specific topics; their distinctive feature lies in the fact that they give the possibility of getting traces of the relationship between the answers given and the capacities brought into play to solve problematic situations of everyday life.

Having into account the simplicity of the test for the age of the applicants and the results depicted in Tables I through V, it can be inferred that a high percentage of students has not acquired basic competencies required to study a university career with the characteristics of bioengineering. It is worth mentioning the seriousness of the difficulties detected, some of which we can mention: incorrect use and/or omission of units, incoherent writing of conclusions and/or wrong wording for the level of study, use of direct rule of three to work out the correct way of making calculations (eg. square root), no respect for instructions, fragmented reading and interpretation of texts, graphs, tables and intervals. In addition, serious spelling mistakes as well as poor handwriting are observed.

From the analysis of the survey about personal data related to future expectations, they show interest in: research (36%), own companies (20%), health centres (40%), and teaching (4%). As for the reason for choosing the career, a 26% of the students state that their choice results from the impossibility of studying medicine. Among the arguments given, they mention economic factors and their not passing the entrance exams.

Further to what has been previously mentioned, it is evident that the 2007 cohort is likely to undergo an early desertion of about 50% in first year, as it has been taking place since quiet a long time ago.

It is considered that what has been found out in this work can be taken as initial reference for institutional decision making in the short and medium term. Firstly, there should be a real articulation with ‘Polimodal’ Level [equivalent to upper secondary school]; currently the school of engineering is carrying out seminars for teachers belonging to the pre-university level so as to achieve this goal. Secondly, actions for academic insertion of students according to their expectations should be implemented in order to promote their permanence in the career they have chosen. In this respect, we suggest the modification of the current system for the implementation of assistantship, starting from the sixth term of the career and continuing in a progressive way.
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