AN ANALYSIS OF PATHS TO RECOVER DEFICIENCIES IN THE LOGICAL-MATHEMATICAL FIELD DURING TWO YEARS OF THE PANDEMIC

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ABSTRACT

Two short university courses of recovery of logical-mathematical deficiencies were completed by 210 students of a degree course in Primary Education Sciences, for future elementary school teachers. The courses were held during the years of the pandemic and were therefore online. Students had completed an entrance test with pen and paper, in person, when they first applied for university. The test was organized by an external organization given that there were more than 1000 candidates. Many deficiencies in logic and mathematics were revealed, but without specifics. We therefore transformed some of the test questions into electronic form, with automatic assessment so that students could verify their level themselves and lecturers could plan teaching activities. These questions were used in the courses of recovery. Having to verify the results of more than 1000 students at the original entrance tests, this method for identifying specific deficiencies of the successful candidates was of great support.

KEYWORDS

Automatic Assessment, Logical-Mathematical Deficiencies, E-Learning, Blended Learning

1. INTRODUCTION

There are three main international assessment systems used to evaluate students in primary and secondary education: the OECD's Programme for International Student Assessment (PISA), (OECD, 2019) that focuses on assessing student competencies in reading, mathematics, and science, with a particular emphasis on problem-solving skills, evaluating 15-year-old students, and is conducted every three years (Mullis et al. 2017); the Progress in International Reading Literacy Study (PIRLS) that focuses on assessing reading comprehension skills of 9-10 year-old students and is conducted every five years (Mullis et al. 2017); the Trends in International Mathematics and Science Study (TIMSS) that focuses on assessing mathematics and science competencies of 9 and 12 year-old students; it is conducted every four years and includes both content and cognitive domains (Mullis et al. 2020). The choice of which program educators wish to use depends on the specific needs of the users. In (Rindermann, 2007) the author conducted a comparative study that analysed data from the PISA, TIMSS, and PIRLS of many countries, and found that the three assessments were strictly correlated. He also found that the results of PISA and TIMSS were strictly correlated with a country's performance in scientific and technological disciplines, such as patent production, research and development, and employment in these fields. Likewise, these assessments can also highlight deficiencies at high-school level. However, the author has also raised some criticisms regarding the limitations of these assessment systems, including the possibility that some nations may improve their performance through intensive preparation for these specific tests, thus not fully representing students' overall educational experience (Rindermann, 2007). Any significant shortcomings of high school students will have repercussions on university performance, with the possibility of numerous dropouts. For instance, in Italy, PISA scores tend to reflect weaknesses in science subjects. Thus, to cope with the difficulties many students have, almost all universities around the world plan recovery or strengthening courses for first-year students.

2. PARTICIPANTS

In the Mediterranean University of Reggio Calabria (MURC), in the 2020/2021 academic year, the number of students with deficiencies in the mathematical and scientific field, detected by a selection test for admission to the degree course in Primary Education Sciences, was 158 out of 250 students admitted to the limited number course, while in the 2021/2022 academic year, 110 students out of 250 were found to be deficient. The number of participants in an offered logic-mathematical remedial course was 210 (instead of 268) in total in the two academic years.

3. METHODOLOGY

In AYs 2020-2021 and 2021-2022, MURC planned two courses during the covid-19 pandemic that took place remotely on the Microsoft Teams platform. The shortcomings of students entering the primary education degree course were highlighted in the results of an entrance test, which is used for admission selection. The entrance test consisted of 80 questions in three areas of essential knowledge, 40 questions are of linguistic competence and logical reasoning, 20 of literary, historical-social and geographical culture and 20 of mathematical-scientific culture. Students who correctly answered less than half of those foreseen in the various fields were obliged to attend a specific remedial course. In the 2020-2021 academic year, all the recovery paths in the three disciplinary areas included 4 hours on the learning methodology (Chiovaro, 2012) and 4 specific hours in the specific areas of competence, which took place in 4 different meetings from 19 April to 7 May 2021. MURC provided a tablet for each enrolled student in AY 2020/2021 and this facilitated the use of different e-learning platforms for exercises, ongoing checks, sharing of materials, and remedial activities. The use of one's own portable device, such as a mobile phone, a tablet or a PC proved to be very useful for activities in different digital learning environments, (Bonanzinga et al. 2020), (Bonanzinga et al. 2022). In the academic year 2021-2022, the courses took place from 23 to 30 June 2022 with 2 meetings of 3 hours each for each area: linguistic and logical, literary, historical-social and geographical, mathematical-scientific. The logical and mathematical deficiencies of incoming university students are analyzed and some strategies for their recovery are presented.

The proposed didactic model suggests a synergistic use of pen-paper and software, (Farihah, 2019), and combines the 5Es instructional model and that of Revised Bloom's Taxonomy (RBT, Anderson et al. 2001). The 5E instructional model is a student-centered model for teaching, which consists of five stages: engagement, exploration, explanation, elaboration and evaluation (Bybee, 1997). As regards the definition of learning outcomes we followed Bloom's taxonomy, reviewed by Anderson et al. in 2001, which provides a list of six categories of skills: remember, understand, apply, analyze, evaluate, create (from the simplest to the most complex), (Anderson et. al. 2001).

In the first phase of the project, the objectives to be achieved according to the model were formulated "S.M.A.R.T." conceived by G. T. Doran and published in the November 1981 issue of Management magazine Review, (Doran, 1981). With the acronym S.M.A.R.T. the characteristics of the objectives to be pursued are indicated:

- Specific: Results should not be too general
- Measurable: the results must be able to be measured, it is therefore necessary to devise methods for quantify progress
- Achievable: the results must be achievable
- Relevant: the desired outcomes must be relevant to the course
- Time-limited: It must be clear how long the goals should be achieved.

Here we present three examples of the questions given to the students, with automatic assessment on the Microsoft Teams platform.

1. A circle has a diameter of 20 cm. The area = (i) 7cm, (ii) 3.5 cm; (iii) 14 cm; (iv) 8 cm.

Twenty-five percent of the students did not know the correct answer to this simple question.

2. A car travels at 36 km/hr. If one wanted to express this speed in meters/seconds it would be = (i) 10m/s; (ii) 127.6 m/s; (iii) 360 m/s; (iv) 36 m/s. Thirty-one percent of the students did not answer correctly.

3. Given a triangle, ABC, if the square built on the side AB has an area = the sum of the squares built on the side BC and AC, the angle at C = (i) right angle; (ii) acute angle, (iii) obtuse angle, (iv) indeterminate angle, there is no data to determine it. Thirty-two percent of the students did not answer correctly.

Albeit these are relatively elementary questions, the percent of students not answering correctly was high.

Having to select some topics to be treated in the recovery paths, it was decided firstly to consider the length of a circumference and the area of the circle. The Teams platform was used. For example, to explain the circumference, pupils were invited to use three different sized objects such as a coin, a cylindrical glass, a cap or other cylindrical objects to draw circles. The circumference of the coin was called C_1; C_2 the circumference of the base of the glass and C_3 the circumference built starting from a cap. Using a piece of tape, the students were asked to measure the circumference and then draw three lines of the three different circumferences and call them L_1, L_2, and L_3. In this way, they obtained the so-called rectified circumferences and after measuring the diameter of the three circles, they then experimentally calculate the ratios between the different lengths of the circumferences L_1, L_2 and L_3 and their respective diameters. They obtained an approximation of π and the inverse formula was obtained, i.e. the length of a circumference is given by the diameter x π, i.e. 2 π r, where r is the radius of the circumference, (Lima and Jordão, 2022). To calculate the area of a circle, we used a model of a pizza and divided it into 4 pieces, then into 8 slices and then into 16. With these 16 pieces the students were asked to lay out the pieces in alternating triangles (up and down). By making the number of slices tend to infinity, we can approximate the area of the circle to that of a rectangle having for base $\pi\times$ r and for height the radius of the circle; they thus obtained the well-known formula for calculating a circle $\pi \times r^2$, (Casselman, 2012).

Secondly, in the context of analytical geometry, straight lines in Cartesian form and the conditions of parallelism and perpendicularity were considered, along with the distance between two points on the plane. Using GeoGebra we showed how to represent points in the Cartesian plane and how to calculate the distance between two points. Furthermore, using the GeoGebra CAS Calculator we have shown how to enter the Cartesian equations of straight lines, how to represent and visualize them in the Cartesian plane and how to verify the conditions of parallelism and perpendicularity, (Hohenwarter, 2002), (Hohenwarter, and Preiner, 2007).

Thirdly, through the toss of a coin or a dice the concept of probability of an event is introduced. The probability of an event is defined for equally probable events and is given by the number of favourable cases divided by the number of possible cases: it was pointed out that this definition applies only when the number of possible cases is finite. Furthermore, statements of mathematical logic were introduced along with application of the negation connective and, in the numerical field, the ordering of rational numbers, expressions with powers and fractions, equations of I and II degree, inequalities of I degree, and decomposition of polynomials of II degree.

4. RESULTS

From the analysis of the entrance tests of the students of the degree course in Primary Education it is clear that the students have greater difficulties in the questions of mathematical logic, in the recognition of a set relationship, through Euler-Venn diagrams, in the decomposition of second-degree polynomials, but also in changing units of measurement, in expressions with powers of rational numbers and in finding a figure that completes a series. The tests administered to students for the recovery of logical-mathematical deficiencies, with an automatic assessment system, proved to be very useful for both students and teachers (Barana et al. 2015), (Bonanzinga et al. 2022). The choice of the April-May recovery activity period proved to be more effective than in June. The students participated with interest in the planned activities and in the questionnaires prepared via Microsoft Teams Forms.

5. CONCLUSION

Questionnaires with Microsoft Teams Forms prove to be a very convenient tool for surveys and for collecting information. The remote teaching activity presented critical issues determined by the difficulty of the internet connection, accentuated by the presence of numerous participants and by the difficulty of verifying the

autonomous progress of the students. Moreover, there is software that allows students' activities to be monitored remotely and sometimes recordings are used to verify the regularity of the tests. Undoubtedly, blended teaching is more effective than distance learning, as it allows for greater student involvement. But in some cases, it is extremely useful for working students, or students with disabilities or who live in very peripheral areas and far from universities, as evidenced by the enormous growth of all online university courses.

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