Global Science Research Journals

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Research Article | Open Access

Global Educational Journal of Science and Technology

ISSN:2465-7190 Vol. 10 (3), pp. 1-11, October 2022

Students skill lacks in accessing scientific degree courses and possible impact on career development: A case study of environmental science course at university of Salerno, Italy

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Received: 09-Jul-2022, Manuscript No. GEJST-22-69009; **Editor assigned:** 12-Jul-2022, PreQC No. GEJST-22-69009 (PQ); **Reviewed:** 26-Jul-2022, QC No GEJST-22-69009; **Revised:** 07-Oct-2022, Manuscript No. GEJST-22-69009 (R**); Published:** 21-Oct-2022, DOI:10.15651/2465-7190.22.10.011.

ABSTRACT

Students' logical mathematical skills are generally assessed as entry requirements for enrolling in scientific degree courses. At university of Salerno enrolled freshmen in environmental science systematically exhibit critical shortage in these skills. As only tiny percentages of students fit the entry requirements, high numbers of students are addressed to attend preliminary remedial courses and pass the relevant exams for obtaining additional learning requirements. In order to get better understanding of the reasons of students' initial difficulties and of the possible impact on subsequent academic career development, a critical analysis has been performed, considering: 1) The results of remedial exams, to identify the most challenging topics; 2) The answers to a survey questionnaire, to acquire information regarding undergraduates' school background and motivations; 3) The results of entry test simulations, to compare high school students' skills with the academic entry requirements. Among the other issues emerged from our study we highlight: a) A worrying disconnection, in students' perception, between the basic science studies and math studies, suggesting a widespread belief that mathematical skills are not fundamental to scientific careers; b) A weak students' intention in the choice of environmental studies. These issues deserve further insight and urgent resolution at university of Salerno but, at the same time, can be framed in a more general perspective and constitute a basis of comparison with other scientific degree courses and other universities.

Keywords: Environmental science degree course, Entry requirements, Entry level skills, Additional learning requirement (OFA), Scientific degree programme (PLS)

INTRODUCTION

Assessment of skill requirements in entry level university courses is a common practice and a matter of wide interest. The question of student preparedness for tertiary instruction has prompted a wide range of qualitative and quantitative studies across disciplines (Libarkin and Anderson, 2005).

Starting from 6 academic years ago, enrolled freshmen in Environmental Science (ES) Bachelor's degree course at University of Salerno, Italy (UNISA) are required to execute the national compulsory entry test TOLC-S, delivered in computer based mode by the Italian inter-university consortium CISIA, and constituted by the sections:

- **Basic math:** 20 questions
- **Basic sciences (chemistry, physics, earth science):** 10 questions
- **Logics/problems:** 10 questions
- **Text comprehension:** 10 questions
- **English (optional):** 10 questions

Every section consisting of multiple choice questions for a total of 50 questions (or 60, with optional English) to be completed in a fixed time; 1 point is given for each correct answer, 0 point for not given answers and a penalty of -0.25 points for incorrect answers. The entry competence assessment for UNISA ES degree course in newly enrolled students mainly concerns mathematics and logics topics, the established criterion for certifying the

minimum required skills being at least 15 points (out of 30) in the TOLC-S “Basic math” and “logics/problems” sections.

All university courses require students to have some level of mathematical skills (Galligan and Hobohm, 2015). Developing quantitative skills, or being academically numerate, is part of the curriculum agenda in science teaching and learning (Quinnel, et al., 2013). Math is indeed a compulsory subject for all the studies belonging to Science, Technology and Engineering (STEM) areas and several studies are reported at any latitude on evaluation of entry level students’ basic mathematical skills, for enrolment in a science or broadly scientific programme (Wilson and MacGillivray, 2007; Coetzee and Mammen, 2017; Abdulkadir et al., 2019).

Mathematics achievement at secondary school has been linked with success in tertiary education (Wilson and MacGillivray, 2007). The importance of mathematical literacy is evidenced by the intense interest of governments of participating countries in international measures of these constructs (Chaman, et al., 2014), like the PISA (Programme for International Student Assessment), an international assessment of student learning outcomes introduced by OECD in year 2000 and aimed to test the fifteen years old students’ key competences considered relevant to afford the society daily problems, including mathematics and science competences.

Mathematical education is considered highly valued also in determining future employing opportunities. Already in 1992 Rivera-Batiz explained how skills level in high school mathematics can be used to predict future qualifications and levels of job satisfaction and income. Naureen and Vicki, (2012) explored the role and importance given by employers to numeracy skills in graduate recruitment within a diversity of employment sectors, highlighting the potential for poor numeracy skills to limit any graduate’s acquisition of employment. Mathematical skills are reported as increasingly important for securing fruitful employment in the modern world (Silva et al., 2016).

The UNISA ES TOLC-S entry test is used as a diagnostic tool rather than a selection tool, since in case the entry criterion is not fulfilled students can still apply to the degree course, but they are assigned additional learning requirements (OFA) and must attend a preliminary remedial math/logics course, passing the relevant exam in order to be admitted to the math exam of the degree course.

The entry evaluation test has a twofold function:

- To promote awareness in students’ orientation towards a scientific degree course, allowing an auto-evaluation of students’ attitudes regarding the minimum math/logics skills required for affording scientific studies.
- To address the students’ deficiencies in the logical-mathematical area, realigning their competences through the OFA procedure including a remedial course and the relevant examination.

In ES degree course at UNISA it has been observed that, every year, high numbers of students attend the OFA remedial courses and have to pass the relevant exam in order to proceed with the regular Math exam foreseen in the first year program. From a review of the last three academic year’s entry test results it has come out that only tiny percentages of students enrolling in ES degree course fit the entry test requirement:

- 7.6% in 2018/19
- 2.2% in 2019/20
- 6.1% in 2020/21

Therefore, most of the enrolled students show insufficient logical-mathematical skills according to the established entry criterion and the OFA procedure is activated for them as a consequence.

The observation of these trends has given rise to a series of crucial questions worthy to be answered for a deeper understanding of the difficulties encountered by aspirant and newly enrolled ES students at UNISA:

- Are the entry criteria too restrictive?
- Are the students not effectively oriented towards the choice of a degree course in line with their real attitudes and competences?
- Are the students not completely aware (maybe not properly informed) about the kind of skills required to afford this degree course?
- Do the students underestimate the basic importance of logical-mathematical skills for this degree course and, if is this the case, what are the reasons?

The relevance of these questions has led us to investigate on aspects that can affect the ES enrolment process and can impact the quality of the enrolled students and of the degree course itself.

University academics across disciplines regularly bemoan undergraduate students’ under preparedness for the mathematical and quantitative demands of undergraduate degree programmes (McAlinden and Noyes, 2019). The issue of poor logical mathematical skills in terminal secondary school year and entry level students of university scientific courses are reported by several studies worldwide, focusing on different aspects like computation, simple problem solving and complex problem solving (Cai, 1995), ‘mathematical’ background to cope with first-year science subjects (Rylands and Coady, 2009), numerical skills and proportional reasoning when dealing with word problems (Coetzee and Mammen, 2017) and exploring the possibility to identify predictors of the student mathematics performance (Mushtaq and Khan, 2012; Siegler et al., 2012; Silva et al., 2016).

Other studies show a significant decline, in the last decades, in mathematical skills regarded by higher education as essential for those undertaking degree courses with a significant mathematical content (Lawson, 2003).

National observatories about students' skills report decreasing trends in the Italian students' competences over the years. The PISA yearly reports generally describe low students' performance in maths and science in Italy. The most recent 2018 report evidences, after year 2012, decreasing trends in Italian pre-university students' performance in science and a rather stable situation in maths, but below the average level of the other OECD participating countries. The negative parable recognized after 2012 characterize, however, the average performance of all the OECD countries.

MATERIALS AND METHODS

Our investigation on the difficulties met by ES degree course entry-level students has been developed in 3 steps:

- Analysis of OFA course and exam.
- Survey questionnaire to students attending OFA courses.
- Simulation of ES entry evaluation test for high school students.
- Analysis of OFA course and exam.

A review of the students' participation to OFA courses and relevant exam results has been performed, concerning the last two academic years 2019/20 and 2020/21. Every remedial course has been organized at the beginning of each academic year in a compact mode (three weeks). After the course, exam sessions have been held with appropriate frequency (2 exam sessions in 2020, 4 exam sessions in 2021) and tutoring activity has been foreseen for supporting students during exam preparation. All the exams have been structured in a TOLC like form, foreseeing 30 multiple choice questions, developed internally at UNISA, afferent to the Basic math and Logics/problems areas, with the same passing criterion of the entry test (minimum 15 points out of 30).

Analysis of Student Groups Attending the OFA Courses

Regarding the years 2019/20 and 2020/21, data have been collected about the number of students: who have failed the TOLC-S entry test, being appointed to attend the OFA courses; who have attended the OFA courses; who have passed the OFA exams. Also the situation of current enrolment in ES degree course has been analysed, to check possible student withdrawals or moving to other degree courses.

Analysis of the Exam Session Results

Due to the COVID-19 pandemic situation, the investigated OFA exam sessions were performed in online modality (home-based), except for the first one (07 Jan 2021) performed in classroom at university.

Exam results have been elaborated using Microsoft Excel 2016.

For each exam session, the % of students passing the exam (with respect to the student's participant in that session) has been calculated.

In order to get specific information on the main difficulties met by the students, all the given test questions have been grouped in topic categories, as follows:

- Basic logics (LOGI)
- Calculation of probability (CP)
- Combinatorics calculation (CC)
- Equations /Disequations (ED)
- Functions (FU)
- Geometry (GE)
- Logarithms (LOGA)
- Monomials/Polinomials (MP)
- Problems (PR)
- Set theory/Numerical series (IN)

For each question in every category the results have been elaborated, separately in each exam session and for all the sessions together, as percentage of correct, incorrect and not given answers. For every category, the arithmetic average and standard deviation of the percentage of correct answers has been calculated for all the questions, in order to have a synthetic value reflecting the general attitude of students towards that topic and the average level of difficulty encountered.

It has to be pointed out that the topic categories are not equally represented: Indeed some categories count a higher number of questions than others, in order to reflect the TOLC entry test structure, which is reproduced in the OFA exam structure. Also from one exam session to another there can be differences in the number of questions for each category. In some exam sessions it hasn't been used the complete set of topic categories (in some cases one or two categories, regarding a small number of questions, have not been used in order to give more space to others).

Survey Questionnaire to Students Attending OFA Courses

The students attending the OFA courses in the last two years 2019/20 and 2020/21 have been asked to answer an online survey questionnaire, developed with Google Forms, for acquiring information about students' educational background, inclinations towards disciplines and motivations regarding the degree course, in order to better understand the reasons of the difficulties met. The

students requested to answer the survey included also who had precociously withdrawn the ES degree course, but excluding the ones enrolled in biological science after scrolling the relevant selection list (since their primary intention to apply to a degree course other than ES was already known).

Simulation of ES Entry Evaluation test for High School Students

The Scientific Degree Programme (PLS) is a plan promoted by the Italian ministry of education and university, aimed to more effectively connect school education and scientific degree courses, opening windows from school to university research and study approaches; main objectives are to guide the choice of high school students willing to pursue scientific academic careers and to build cooperative formation activities in order to empower students' and teachers' skills in scientific field (Supplementary Figure 1).

Within the 2021 PLS program involving ES degree course, from February to June 2021 several online training activities have been organized by UNISA, addressed to students and teachers of the high schools in the territory, focusing on environmental field and correlated disciplines; it has represented also an opportunity to emphasize the importance, for a career in environmental Science and scientific studies in general, of solid math, logics, critical reasoning and problem solving competences, as well as a good sensitivity towards meaning and manipulation of numerical data, necessary to give physical sense to phenomena and scientific observations. In this direction, 3 online sessions of TOLC-S entry test simulations have been organized, aimed to provide high school students with a tool for auto-evaluating their skills with respect to the degree course entry requirements and, at the same time, to create an opportunity of involvement of high school teachers, offering them an overview of the exit skills required, at completion of high school, for students willing to proceed with scientific studies.

The simulations, developed internally at UNISA using the online quiz creator "QuestBase", were based on the TOLC-S "basic math" and "logics/problems" sections, with type and number of questions, completion time and scoring system comparable to the real entry test, and were performed in computer based mode.

14 high schools in the UNISA typical catchment area have been involved in the simulations, with 285 participant students, mainly from the terminal school classes but also from the first and second last years. The students were mainly from scientific Lyceum, with a minority from classical/other types of Lyceum and from technical institutes with major in Chemistry.

Questions were divided into the same topic categories of the OFA exam tests, so that results could be analysed with respect to those categories with the same modalities applied to OFA results, generating comparable data elaborations. So the percentages of correct, incorrect and not given answers have been calculated per single question, and the average percentages of correct answers have been obtained per each topic category.

RESULTS

Analysis of OFA Course and Exam Results

Analysis of student groups attending the OFA courses: In the period of investigation 184 students have failed to fulfil the TOLC-S entry test criterion for enrolment in ES and have been appointed to attend the OFA courses. The courses have been followed by 170 students, the remaining number including students who have moved to Biological Science after scrolling of the selection lists or have applied to ES but renounced afterwards, or are still enrolled in ES but have not attended the OFA course. Out of the 170 students attending the OFA courses, 110 have succeeded in passing the exam (sometimes after two or more attempts), while the others have not taken or have not passed the exam yet.

Looking at the enrolment situation we have observed that, out of the 170 students attending the OFA courses in years 2019/20 and 2020/21, 68 students are not currently enrolled in the ES degree course anymore, having moved to other courses or having renounced to studying (Table 1).

Table 1: Situation of student's enrolment in environmental science after attending OFA course in years 2019/20 and 2020/21.

Nr Students	OFA course attended	OFA exam taken/passed	Enrolment situation
15	yes	no	Renounced after application or not renewed application in the following years
20	yes	no	Not intentioned to apply to ES, but applied to Biological Science after waiting for scrolling of selection list (ES second choice)

13	yes	no	Applied to other degree courses (chemistry, pharmacy, nursing sciences and others)
17	yes	yes	Renounced after application or not renewed application in the following years
3	yes	yes	Not intentioned to apply to ES, but applied to biological science after waiting for scrolling of selection list (ES second choice)

68 students, out of 170 attending OFA courses in 2019/20 and 2020/21 (40%), are not currently enrolled in ES

Analysis of the Exam Session Results

Excluding the first exam session, performed in different conditions than the other, the % of students passing the exam in each session with respect to the participant students is in the range from 40% to 67% (Table 2).

Table 2: Analysis of OFA exam results: % of students passing the exam at each exam sessions.

Exam session date	Nr participant students	Nr students passing the exam	% students passing the exam
07-Jan-20	63	53	84,1
27-Jul-20	22	13	59,1
08-Jan-21	39	21	53,8
25-Jan-21	25	10	40,0
25-Feb-21	9	6	66,7
22-Mar-21	8	4	50,0

Supplementary Table 1 summarizes the calculated percentage of correct answers for the single questions, grouped by topic category, and the average percentage of correct answers for all questions in each category. The values below 50% are evidenced. As the questions constituting each topic category were of different type and grade of complexity, there is a large variability in the percentages of correct answers among each category (Figure 1). The high values of the calculated standard deviations reflect this variability.

Figure 1 represents the average percentage of correct answers in each topic category for all the exam sessions, with categories sorted from the lowest percentage to the highest.

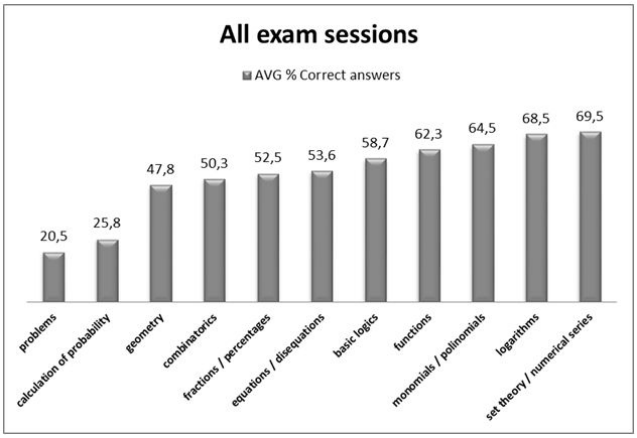

Figure 1: Analysis of OFA exam results: Average % correct answers per topic category in all OFA exam sessions, ordered from the lowest to the highest value.

Survey Questionnaire to Students Attending OFA Courses: Analysis of Answers

Out of 150 questionnaires delivered, 111 answers have been gathered, as the other students, mostly the ones not enrolled anymore in ES at UNISA, have refused to participate in the survey.

The analysed sample of students is composed of 60, 4% female and 39, 6% male students.

The educational background of the examined students are very diversified, as many types of high schools of provenance are involved (Figure 2): A large number of students come from Scientific Lyceum (grammar school with major in Scientific subjects), while the others are distributed in different types of schools with different specializations (other kinds of Lyceum, Technical schools, VET schools). Also the specific institutes of provenance and their locations are very different, with no large clusters of students coming from the same institute (the most numerous groups of students attending the same type of educational curriculum in the same institute are formed by 4 students).

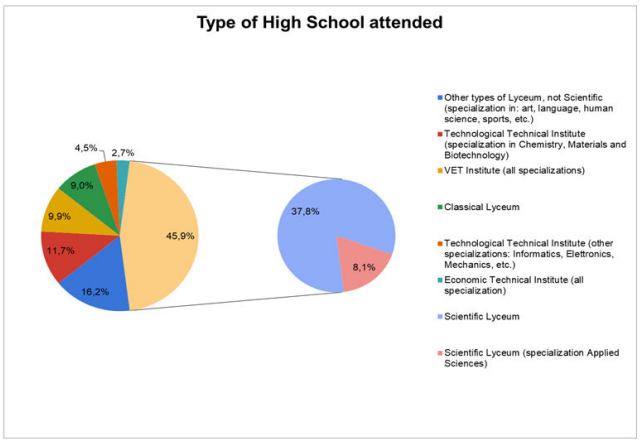

Figure 2: Survey questionnaire: Type of high school attended.

The small diagram is referred to the schools with major in science: Scientific Lyceum and scientific Lyceum (specialization in applied sciences).

High heterogeneity is also shown looking at the students' final diploma mark (Figure 3), with a varying distribution in all the vote ranges from the minimum (60-65/100) to the maximum (100/100, 100/100 cum laude); the total percentage of marks in the high ranges (from 81/100 to 100/100 cum laude) is comparable to the total percentage of marks in the medium-low ranges (from 60/100 to 80/100).

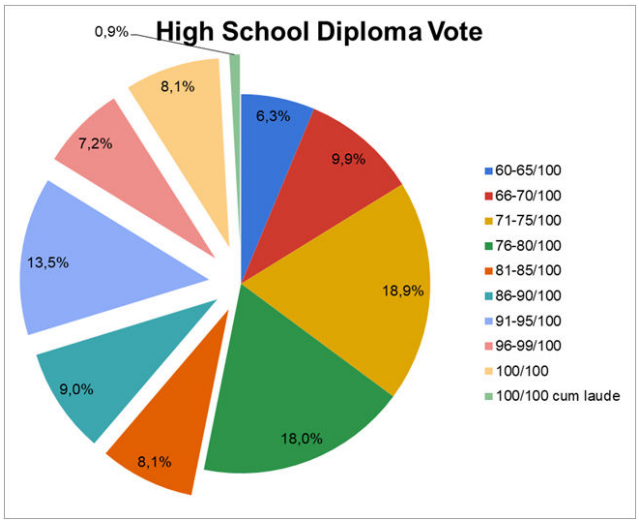

Figure 3: Survey questionnaire: High school diploma vote.

The % corresponding to medium-high votes (from 81/100 to 100/100 laude) are put in evidence.

The most students who have attended OFA courses in years 2019/20 and 2020/21 had enrolled in the degree course in the same years, but a significant number (around 18%) enrolled in previous years (2018/19, 2017/18 or earlier), delaying the remedial process more than expected (Supplementary Figure 2).

More than 80% of the interviewed students is currently attending ES degree course at UNISA but, a part from a small physiological percentage of study abandonment, a significant percentage (around 14%) has moved to other degree courses at UNISA or another university, or have enrolled in ES at another university (Supplementary Figure 3). It has been asked to the students not enrolled anymore in ES at UNISA about the reasons of their change; the most frequent answer is that they realized to be more interested in other subjects and studies; other less frequent answers, in decreasing order of occurrence, regard topics not in line with their expectations; course organization and programs not in line with their preferences; logistic problems; decision to follow the choice of friends; belief that other degree courses could offer more job opportunities; received information that the same degree course would have been easier at other universities.

The majority of the students still attending ES at UNISA declare to be on track with their studies, but around 24% is in delay with the exams.

The students have been asked about their attitudes and preferences towards the study of the various disciplines belonging to their high school curriculum (Figure 4): the most favourite discipline, for about one half of the students, was basic sciences (Biology, Chemistry, Earth Science), with the other half expressing very diversified preferences, but only 9,0% preferred math. The situation is very similar if we sort the answers for the only scientific

school students (Scientific Lyceum), whose favourite subject was still basic sciences for one half of the students, with math attested to the low value of 14.0% (Supplementary Figure 4). If we look at physics, a tiny percentage of students expressed preference towards this subject, both considering all students and only scientific Lyceum students.

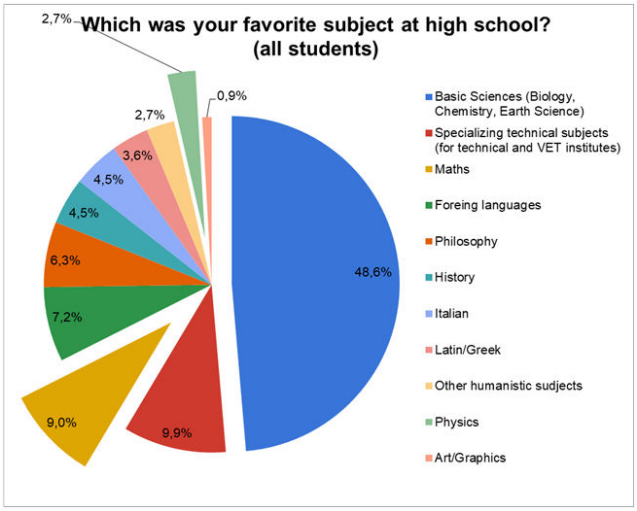

Figure 4: Survey questionnaire: Favourite subject at high school (considering all students).

On the other hand, when asking about students' least favourite subject at high school, the highest percentage has been reached for math and lowest for basic science (Figure 5). If only scientific high school students are considered, the percentage expressed for Math is lower but it is anyway the third not favourite subject (Supplementary Figure 5).

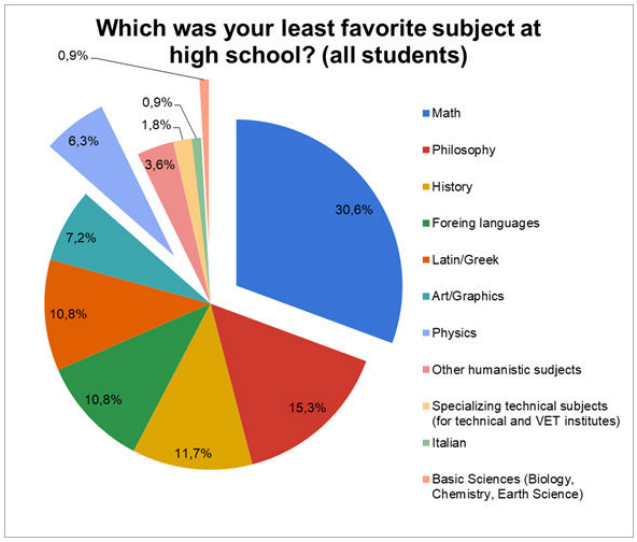

Figure 5: Survey questionnaire: Least favourite subject at high school (considering all students).

The students have been asked if, during high school, they had followed any university orientation program, like the national Scientific Degree Plan (PLS). The majority of them (about 64%) have answered negatively.

It has been asked if, before applying to ES degree course, students knew about the compulsory entry test to perform. Most students (about 61%) state they knew about the test and what it concerned, but a relevant number of students just knew about it without having a precise idea of what it concerned or didn't know about it at all (Supplementary Figure 6). The students who were well informed about the test and its content also say that they afforded a study preparation for the test, consisting in large majority of studying in autonomy (alone or with friends) based on simulations and tests of the previous years; only very tiny percentages of students studied with the guide of study centres or teachers (Supplementary Figure 7).

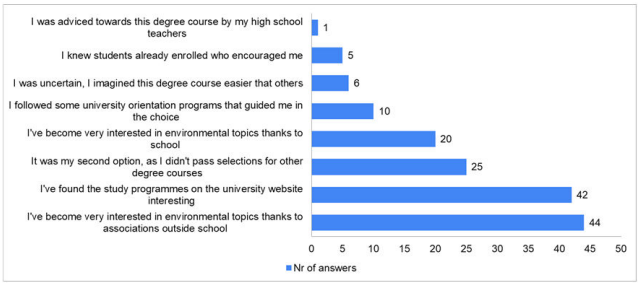

Figure 6: Survey questionnaire: reasons for choosing Environmental Science degree course.

At the question if their high school teachers had ever presented to the students any TOLC test or similar university entry test, in order to explain them or give support during resolution, the huge majority of students (about 92%) answered that this never happened; all the other students said that this happened sometimes, while no students chose the answer option that their teachers used to do that frequently.

When asked if the "logical thinking" approach was generally used in high school lessons, only about 40% of students answered positively, indicating the subjects in which this approach was most frequently applied: the highest percentage is relevant to math, while basic sciences has been attributed a low percentage, lower than philosophy, and physics' percentage is among the lowest ones (Figure 7).

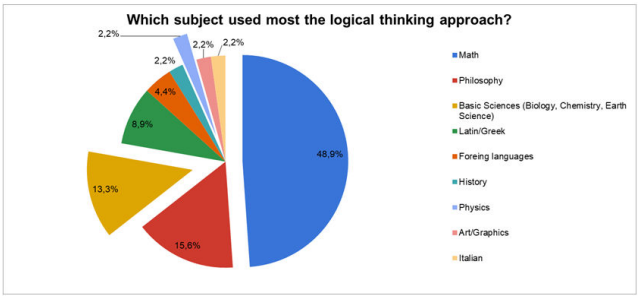

Figure 7: Survey questionnaire: high school subjects using most logical thinking approach.

At the question if students effectively acquired the concept of "scientific method" at high school, a little more

than 50% answered negatively; the ones answering 'yes' gave indications of the disciplines in which this topic was most extensively treated, with the highest percentage attributed to basic sciences, followed by math, then physics and then the other subjects (diagram in Supplementary Figure 8). Limited to scientific Lyceum, a large majority of students thinks they have effectively acquired the concept of "scientific method" at school, anyway attributing the most of this learning to the same scientific subjects appointed by the overall group of students, and in the same order of relevance (Supplementary Figure 9).

In order to check students' perception and auto-evaluation capacity about their difficulties in logical-mathematical topics, it has been asked which topic categories they consider most difficult, among the ones coded for the OFA exam questions (maximum two choices were allowed) (Figure 8): the survey results are not completely aligned to the OFA exams results, as students theoretically supposed to have more difficulties, in decreasing order, in "combinatorics", "geometry" and "calculation of probability", categories clearly emerged as the top weaknesses also from the exams data analysis; even though they regard "problems" as an issue, students in the survey don't recognize this category as the most challenging one, in contrast to what demonstrated by the OFA exams outcomes. An explanation of this can lie in possible students' partial unawareness of their lacks in logical mathematical reasoning.

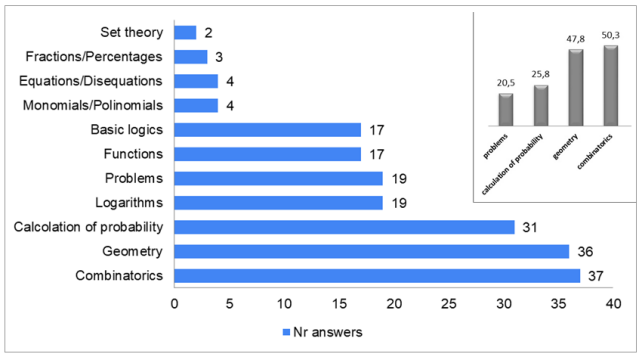

Figure 8: Survey questionnaire: Most difficult topic categories in OFA exams, according to students' opinions (the small box reports a detail of Figure, with the average % of correct answers in the topic categories resulted most difficult from the analysis of OFA exam data).

About 20% of the interviewed students have not passed the OFA exam yet. Among the ones who have passed it, an appreciable percentage (more than 30%) needed more exam sessions to reach the goal, since they didn't manage at first attempt after following the course (Supplementary Figure 10).

The last question was aimed to catch students' perception about the additional learning requirement process: About 40% of students recognize its function of support for better affording the degree course math exam, while about one half of the students consider the OFA as an additional exam delaying their academic career and about 12% see it as a moment of reflection about their choice of pursuing scientific studies (Supplementary Figure 11).

Simulation of ES Entry Evaluation Test for High School Students: Analysis of Results

Supplementary Table 2 summarizes the calculated percentage of correct answers for the single questions, grouped by topic category, and the average percentage of correct answers for all questions in each category.

Figure 9 represents the average percentage of correct answers in each topic category for all the exam sessions; the categories are sorted from the lowest percentage to the highest.

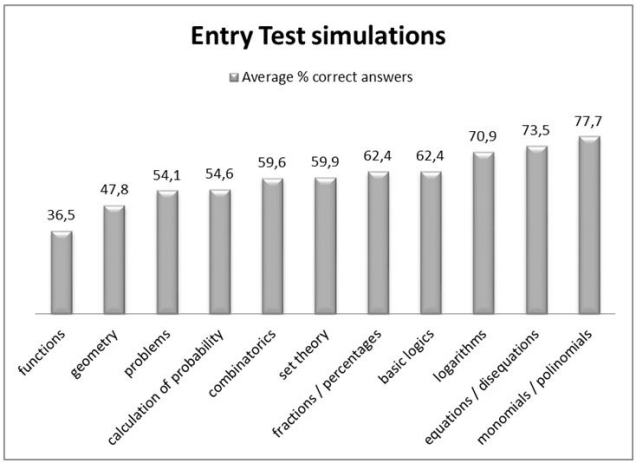

Figure 9: Analysis of entry test simulations: Average % correct answers per topic categories.

Even though not completely overlapping to the OFA exams results, it can be noticed that, with the only exception of "functions", the lowest percentages of correct answers are found in the categories "geometry", "problems" and "calculation of probability", that emerged as the most challenging categories also in OFA exams, although in different order. The difficulties met in "functions" questions can be likely related to the fact that this topic belongs to the last year curriculum, while a large number of participant students were attending previous classes.

If the ES entry test passing criterion is considered (minimum 15 points out of 30), the pool of students fulfilling this requirement corresponds to 57.9% of all the participants. (Supplementary Figures 11 and 12 shows the scores obtained by each of the 285 students).

DISCUSSION

Considerations arising from the analysis of OFA exams results can be focused on the low level of performance in

"problems", revealing a lacking attitude of the examined students towards the reasoning and logical processes necessary for applying basic math notions to scientific problem resolution. This skill shortcoming can be difficult to remedy in the short period of the OFA course. Benadusi, et al., (2005) had already reported a worrying deficit, emerging from the PISA comparative data of math and science literacy indicators, of the Italian pre-university students with respect to the average of the other OECD European and world countries; this deficiency was referred in particular to the performance requiring reasoning and argumentation abilities, as well as ability of application to real context problems, which has been considered not in line with the contemporary society needs. The authors primarily attributed this low performance results to the prevalence of traditional, notion based and experience disconnected didactic methodologies for the scientific disciplines, and also to the Italian historical humanistic cultural hegemony. Still nowadays, more than 15 years after this analysis, there are indications that the origin of these students' difficulties can be found in a poor use of problem solving approaches at school, with teachers applying didactic methodologies unable to transmit the appropriate association between science and logical mathematical thinking.

The difficulties in "calculation of probability", the second most challenging category for students in OFA exams, can be attributed to the fact that this topic is not generally foreseen in the didactic programs of the different types of secondary schools, being not easily recoverable successively. Mathematics teachers and lecturers need to be aware of students' difficulties and ought to attempt to assist them to overcome such challenges (Coetzee and Mammen, 2017).

Looking at the educational background and final diploma mark of the examined students, it can be assumed that the logical-mathematical skill deficiencies evidenced during the TOLC entry tests and largely confirmed during the OFA exams are attributable to a generalized problem, not dependent on the type of high school attended or the specific institute of provenance, and not apparently correlated to the students' attitudes to studying as indicated by their school marks; with this latter regard, it could be also hypothesized that the definition of students' performance results at high school don't take much into account evaluation of their logical mathematical competences, or that competence standards at high school exit level are lower than what required at university entry level.

The entry test simulation results indicate, on the whole, better students' performance than the OFA exam results: this can be explained by the fact that participants in PLS programs are generally selected by their teachers among the best students in their respective high schools, thus not reflecting the more heterogeneous pool of students enrolled to the degree course.

Also from the survey questionnaire answers it clearly emerges an apparent disconnection, in students' perception, between the basic science studies (Biology, Chemistry, Earth science) and math studies. Students applying to ES degree course at UNISA show good attitude and preference towards science (which has likely influenced their choice of pursuing a study career in the environmental science field) but not towards Math, suggesting a widespread belief, among students, that mathematical skills are not fundamental to scientific studies. It is reasonable to suppose that these students, at the moment of application to ES degree course, are not completely aware of the central role attributed to the logical-mathematical skills for the access to the degree course (entry test requirements) and for the continuation of the course itself. Further investigation is required about the origin of this misconception and which responsibilities, if any, can be attributed to secondary school and university with this regard. Quinnel, et al., (2013) had previously reported a similar rigidity of mind in students, a "standoff" forming a barrier to 'do maths' as part of 'doing science', which leads to disengagement from learning; as fluid thinking and application of numeracy skills are required to manipulate experimental data sets and are integral to science practice, the authors think it's necessary to stop students from seeing them as optional 'maths' within the discipline, being explicit about the ways those in the discipline think, how quantitative data is processed, and allowing places for students to address their skills (including their confidence). Jackson and Johnson (2013) report about the maths skills programme developed to address under preparation in the first year science cohort of the Australian La Trobe university, in which an alternative model was offered for mathematics support tailored to science disciplines, designed through close collaboration between science subject coordinators and mathematicians and focused on basic mathematical skills relevant to each science discipline; evaluation of the programme showed it improved the confidence of the participating students who found it helpful and relevant.

Other authors describe a postsecondary remediation program in mathematics, consisting of voluntary bridging education in the format of an online summer course aiming to ease the transition from high school to university and to improve the success rates in the first year of bachelor studies.

Analysis of students' answers about motivations leading them towards environmental science studies gives rise to some important considerations and to reflections about consequent remodelling of the orientation strategies:

The preponderant role in promoting students' interest towards the environmental issues is played by associations outside school, rather than the educational institutions (school and university).

Negligible appears, in students' perception, the role of high school teachers in guiding students in the choice of the degree course.

Structured university orientation programs (like the national PLS) are not followed by the majority of students, who don't benefit from the specific and accredited formation, coming from university experts, about the course contents, opportunities and difficulties. On the other hand, noteworthy is the number of students finding the degree course study plans on the university website interesting and supporting for their choice, thus confirming the importance of multimedia as vehicle of information and involvement for young people.

A consistent number of students considered the ES degree course a "second choice", as they didn't pass selections for entering other courses they were more interested in.

A certain weakness in the students' intentions towards the ES choice has emerged from our study. A very recent study performed by CISIA, about to be published in October 2021 and anticipated by an Italian newspaper, reveals a generalized difficulty of the Italian students in the choice of their future academic career, a poor participation of high school students to orientation activities organized by university and a high rate of students withdrawal in the first academic years. Also the AlmaLaurea Report about profile and occupational condition of Italian graduates in 2020 indicates that the number of students who express unawareness about the reasons of their university choice is increasing. It is important to remind that scientific degree courses are challenging and selective, requiring commitment and considerable cognitive skills; a solid basic preparedness but also strong motivations are needed to accomplish the course (Benadusi, et al., 2005). Weak intentions, combined with initial difficulties in fulfilling the entry skill requirements, can be placed among the reasons of the registered first years withdrawals. It is already reported that the consequences of failure in an introductory mathematics course can be significant and may contribute to decrease the undergraduate student rates of entry into and persistence in the degree course (Gupta, et al., 2006). The high percentage of students withdrawn from ES degree course after attending the OFA remedial courses in the investigated period (40% of the total students attending the OFA courses in that period) can be considered a negatively impacting factor for the efficiency of the degree course itself, as time, resources and organizational features are implied in favour of inconclusive students or of students interested in other degree courses. From this perspective, the OFA process could be appropriately used also as an orientation tool, able to dissuade unmotivated students from applying to the ES course, provided that they are preliminary informed of the consequences of not achieving the additional learning requirements. Moreover, in order to reinforce its orientation value, it can be suggested that the OFA exam is propaedeutic not only to the math exam, but to all the exams foreseen by the ES program.

From the survey it emerges that not all the students attribute the proper weight to the OFA process, as the highest percentage considers it an additional exam delaying the career. It is true that, in a significant number of cases, the time needed to recover the initial non-compliance with the entry skill requirements is longer than expected (many students need more attempts to pass the OFA exam) and this can impact on the normal length of academic course.

CONCLUSION

The results of this study indicate that higher order issues can be considered at the root of the ES entry level students' difficulties, deserving a further insight.

The poor connection between science education and logical mathematical skills, as emerged from our study and documented by previous studies, would require a deep reflection about all the educational levels, with involvement of developers and implementers of curriculum programs and didactic methodologies in school districts and at larger extent.

At the same time careful reflection should be encouraged in order to define, as a matter of urgency, more effective orientation strategies, possibly cooperative between universities and high schools, to support choice of university course with increased awareness and motivation. University and high school should also put in place synergic programs for more effectively connecting the different levels of education, both in the frame of existing plans (like PLS) and introducing new cooperation schemes. University should be more present at high school, fostering activities for bridging schools to academic paths, research processes and higher education approaches.

It is certainly necessary a more adequate definition of the competences that students should possess at completion of secondary school in order to afford a scientific academic career in the environmental field, focusing in particular on the areas whose lacks have been extensively documented. The entry requirements for environmental science studies, including the logical-mathematical skills, should be made very clear and well known to high school teachers and students, in order to approach school programs to Galileo's concept that "nature is written in mathematical language".

At the same time it should be more incisively clarified the responsibility and commitment of school teachers in providing support and continuity to the students' future study choices, a role that naturally suits them for their practice and ability to intercept the students' competences, lacks, inclinations and motivations.

We can conclude that students willing to pursue a career in the environmental science field should be guided to do that with the proper cognition; at the same time, it's crucial to create the conditions for achieving a scientifically valuable environmental education and for increasing the "quality" of students in order to assure formation of competences able to adequately respond to the society needs and the global environmental challenges.

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