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Investigating STEM course choices through physics knowledge surveys

Un'indagine sulla scelta di corsi STEM dall'analisi di questionari di fisica

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Abstract
The choice of STEM courses is often influenced by previous educational career. In particular, in the scientific field, the learning of specific and at the same time paradigmatic topics plays a fundamental role. This research aims to assess nuclear physics knowledge in a sample of high school and university students through a multiple-choice survey. We analyzed and compared the results between the two samples and against a fixed threshold value. We also examined subgroups within the high school and university samples. The study considered influences from school background, learning continuity, and gender differences. We found a significant correlation between teaching hours and test results. The analysis provides insights into physics education and the quantitative relationship between teaching and knowledge acquisition. A specialistic knowledge that students can use as a tool for orientation towards STEM university choices.

Keywords: STEM; Gender Balance; Education; Survey; Nuclear Physics.

Riassunto
La scelta di corsi STEM è spesso influenzata dalla carriera scolastica precedente. In particolare nell'ambito scientifico giocano un ruolo fondamentale gli apprendimenti specifici e al tempo stesso paradigmatici di una disciplina. L'obiettivo di questa ricerca è quindi di monitorare lo stato dell'arte dell'apprendimento di uno specifico settore della fisica, la fisica nucleare, in un campione di studenti delle scuole superiori e dell'università, attraverso un'indagine con test a risposta multipla. In questo lavoro, i risultati del questionario tra i due campioni sono stati analizzati e confrontati con un valore di riferimento fisso. Sono stati inoltre confrontati i due campioni (scuole superiori e università) e le loro sottocomponenti. Sono state considerate le influenze determinate dall'origine scolastica, dalla continuità didattica e dalle differenze di genere. È stata analizzata la correlazione tra il numero di ore di insegnamento e i risultati ottenuti, che ha fornito un risultato significativo. Pertanto, l'analisi dei risultati può essere un buon campo di indagine nella didattica della fisica per studiare la relazione quantitativa tra l'insegnamento e l'acquisizione di conoscenze che possono essere utilizzate dallo studente come strumento di orientamento verso la scelta universitaria in ambito STEM.

Parole chiave: STEM; Equilibrio Di Genere; Didattica; Questionario; Fisica Nucleare.

1. Introduction

1.1 Description of the institutional context

Regulatory changes implemented in Italy between 2008 and 2010 aimed to simplify the organization of teaching systems and guidelines, and to reorganize school curricula. Table 1 shows the current school levels in Italy. These interventions significantly impacted the high school level.

School level	Student age	Duration
Nursery	0-3	3
Primary school	3-6	3
Primary School	6-11	5
Secondary School	11-14	3
High School	14-19	5
University	19-25 (max)	2 to 6

Table 1: Levels of the Italian school (Italian ministry of education and merit, MIM, 2024).

The liceo scientifico, one of the cycles of studies in the second level of secondary school (high schools) aimed at preparing students for STEM university courses, underwent a profound transformation of its timetables. This transformation included increases in teaching hours for physics, mathematics, computer science, and natural sciences. Alongside the Traditional Scientific Curriculum (TSC, "Liceo scientifico tradizionale" in Italian), an Applied Scientific Curriculum (ASC, "Liceo scientifico opzione scienze applicate" in Italian) was introduced. The ASC emphasizes the teaching of certain scientific disciplines, such as computer science and natural sciences, with the latter including chemistry, biology, and Earth sciences (Table 2). These changes generated expectations for improved student education in the scientific field, a need that had been recognized since the late 20th century (Borghi, 2000; Presidential Decree DPR 89/2010). Concurrent with this innovation, school monitoring was strengthened through standardized tests, enhancing the role of the National Institute for the Evaluation of the School System (INVALSI). This included the use of international tests such as OECD-PISA. This approach has allowed for detailed analyses of specific subjects, such as Italian, English, and Mathematics for the TSC+ASC. The results of these tests are publicly available and can be accessed via the "Scuola in chiaro" channel for each institution and class. However, physics learning is not monitored with the support of an institutional assessment structure. Nevertheless, valuable information can still be obtained from sector studies on individual learning areas and with study samples limited to restricted territories, to guide potential interventions in modifying educational strategies (Zani & Bozzi, 2018).

Year	Maths			Computer Science			Physics			Natural Science		
	LS*	TSC	ASC	LS*	TSC	ASC	LS*	TSC	ASC	LS*	TSC	ASC
I	5	-	-	-	-	+2	-	+2	+2	-	+2	+3
II	4	+1	+1	-	-	+2	-	+2	+2	-	+2	+4
III	3	+1	+1	-	-	+2	2	+1	+1	2	+1	+3
IV	3	+1	+1	-	-	+2	3	-	-	3	-	+2
V	3	+1	+1	-	-	+2	3	-	-	3	-	+2

Table 2: Timetable of scientific disciplines in the TSC (Traditional Scientific Curriculum after 2010) and ASC (Applied Scientific Curriculum after 2010) compared with the liceo scientifico (LS*: scientific curriculum before 2008-2010). For the TSC and ASC, hourly increases compared to LS* are indicated.

1.2 Nuclear physics education

In Italy, the simplification of the educational offer through the 2008-2010 reorganization, primarily based on reducing study courses and experimentations, has not been matched by clarity on educational objectives and content, especially for scientific disciplines and particularly for physics. In place of now inadequate and plethoric school curricula, so-called ministerial programs (Maragliano, 1997), not always specific national guidelines have been imposed in "Linee generali e competenze" (general lines and competences). Regarding physics teaching, teacher discretion attributable to the freedom of teaching has widened.

Concerning nuclear physics, it is mentioned only in the "National guidelines for scientific high school" and solely as a field for verifying the equivalence of mass-energy in light of the theory of special relativity. In the 54 pages of the ministerial document, only one line is dedicated to nuclear physics (Education Ministerial Decree D.M. 211 7/10/2010). These elements lead to an inexplicable gap in the educational-training process of students. According to this approach, many students will not become aware of the fundamental contents of nuclear physics, related to the description of the nucleus, their decays and reactions, nuclear applications in energy issues, medical and cultural heritage fields, as well as in basic research (Brigazzi, 2010). To address these issues, subjects involved in nuclear physics, such as universities, polytechnic schools, research centers, the Istituto Nazionale di Fisica Nucleare (INFN), and other institutions (Ministry of Education, Italian government) have developed a renewed interest in teaching and its improvement.

In this context, it is evident that while the educational offer in the scientific field has expanded quantitatively, this has often occurred in favor of sections of classical physics (Education Ministerial Decree D.M. 211 7/10/2010), in some cases modern physics (atomism, relativity), and little or not at all as far as nuclear physics is concerned. The situation is exacerbated by the training and updating activities of teachers, who are the real decision-makers of their teaching activity curves. Often, most of them do not have a solid preparation in the field of nuclear physics, either because they have degrees in mathematics or engineering or because, even if they have degrees in physics, they have not studied nuclear physics in depth. This suggests that student preparation in this area is not adequate for the study prospects of those who intend to continue with STEM and, more generally, to make conscious choices of active global citizenship that involve an adequate reference background in nuclear physics (Burcham, 1956; Wellington, 1982; Zeidler, 2016). Other authors in the past have stressed that nuclear issues are not particularly exciting or relevant to students because they are outside their personal experiences (Shamos, 1995; Zeidler , 2005).

Instead, the important contribution that nuclear physics would bring to STEM students and more generally to citizens corresponds to a completely accessory role in the Italian scholastic framework (Achiam, 2016). Teaching nuclear physics would also contribute to reducing the gender gap in STEM choice. It is interesting to note that unlike other nations, the percentage of cis-female students who complete scientific high school and access STEM courses is very high in Italy, and gender inequality is more limited than in other European states (Eurostat). However, the overall number of students enrolled in STEM courses is low. It remains to be highlighted that these students often enroll in degree courses aimed at teaching and personal care, while they are much less present in scientific degree courses in the strict sense or economics (Figure 1, latest available data 2020) (Carriero, 2022).

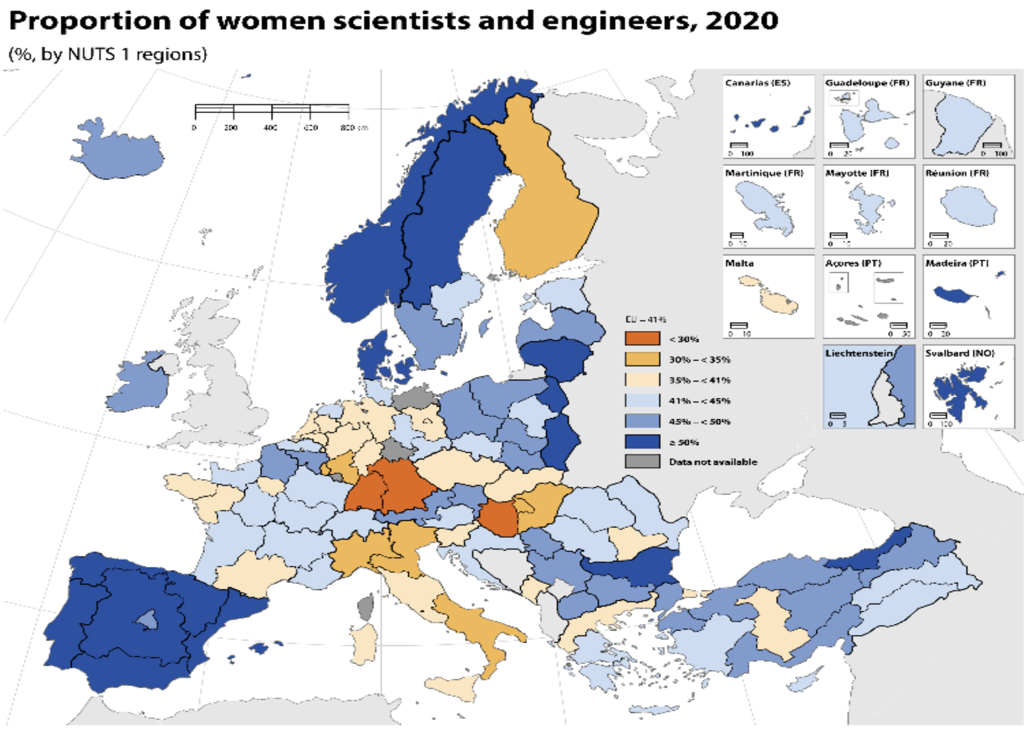

Figure 1: Percentage of women scientists and engineers (2020), gender gap referred to graduated female students in Europe in 2020 (Eurostat source)

The survey presented here is part of the activities aimed at innovation of the European Higher Education Area (EHEA), also considering the Bologna process. In recent years, to realize this aim, some authors have exploited both the introduction of experimental activities as well as the use of augmented reality (Restivo, 2014; Viegas, 2007). As regards the teaching of nuclear physics, these innovations have not yet been implemented, and there is a lack in the reference literature.

2. Materials and Methods

2.1 Research methodology

To assess the state of nuclear physics knowledge among students transitioning from high school to university, and to correlate their educational experience with learning outcomes, we selected several samples. We administered a questionnaire to obtain quantitative results regarding the situation. To maintain a focused and non-dispersive picture, we analyzed groups of students from scientific high schools or enrolled in the first year of STEM university courses. Specifically, the questionnaire was administered to first-year university students in Physics (group PH) and Biomedical Engineering (group BE) degree courses, before they undertook courses in modern physics, during the second semester of their first year. These two samples, which include all enrolled students without pre-selection, were chosen as representative of a theoretical degree course (Physics) and a technical one (Biomedical Engineering). Subsequently, the questionnaire was administered to a sample of students in the final year of high school from the Monza and Brianza high school network, which includes three scientific high schools, referred to in this work as liceo I, liceo II, and liceo III. These institutes partly cover the catchment area of the universities to which groups PH and BE belong. In this second round, the questionnaire was administered at the end of the course of study. The questionnaire was administered face-to-face to avoid external influences and to standardize the performance setting, in a context observed by the administrator. To bring together homogeneous and numerous samples operating simultaneously, we preferred to collect information through CAWI (Computer Assisted Web Interviewing) and BYOD (Bring Your Own Device) methods (Cheung & Hew, 2009), using shared mailing lists and social communities, which also allowed for easy data analysis. The choices of settings, operating methods, and sample composition have prevented the occurrence of critical issues generally linked to sample subsets with low digital literacy, which in other statistical contexts have made the dual channel CATI (Computer Assisted Telephone Interview)/CAWI method preferable to pure CAWI (De Leeuw, 2005).

2.2 Test structure

The questionnaire consists of two blocks of items (Guidicini, 2012). The first block relates to information about the subjects in the sample, while the second contains questions about their knowledge of nuclear physics fundamentals. Given that the questionnaire is not intended as a tool for assessing skills/competences through self-correction or suggestions, we designed it according to the classic CTT (Classical Test Theory) formulation with closed-answer items (Ellis & Mead, 2004). This approach was preferred over the IRT theory (Item Response Theory) (Baker, 2001). For the same reason, we chose not to administer funnel or inverted funnel questions. Instead, the order of the questions was varied for each participant to avoid context conditioning (Jamsen & Corley, 2007). Control questions were also added to evaluate the reliability of individual questionnaires (Iezzi, 2009). The nuclear physics section comprises 28 questions, each with four possible answers, only one of which is correct. The questions were established bearing in mind that any structured training of the student in formal contexts also took place through the study of school textbooks (see Suppl. Mat.). Eight questions were related to narrative-type notions; nine to complex-level notions; and eleven to applied field notions. The term "narrative" refers to specific contents of nuclear physics (isotope, nucleus, decay...) of an elementary or primitive type, which can be learned through simple-level teaching. "Complex" notions are attributed a value of correlation with other contents through more or less simple theories and with possible formalization. Finally, "application" refers to knowledge in experimental fields, research, civil use of nuclear energy, and medical physics necessary for the informed citizen.

Three control questions were included in the questionnaire: two in the descriptive items section and one in the complex items section. A control question is identical to one already assigned; if a student answers the two identical questions in the same way, this proves that the questionnaire is not approached superficially. The responses of subjects who answered differently to the control questions were not considered in this research. The attribution of a single score to the correct answers made it possible to make comparisons between the different samples of students. An acceptability threshold S was set, considering that the student's minimum preparation should include all the narrative contents (8 points), and 25% of complex and application contents ($0.25 \times 11 + 0.25 \times 9$), corresponding to the score achievable in the case of random answers. The value of S in terms of score is therefore equal to $S = 8+9/4+11/4 = 13$. This way, the acceptability threshold corresponds to the possession of simple narrative contents. If a student had answered all the questions randomly, they would have scored an average of 7/28. Verifying a correlation between the effective quantitative teaching (hours of frontal lessons) of nuclear physics and the passing of S is one of the aims of this work.

2.3 Validation

The multiple-choice test was conceived within a PhD project in Physics Didactics of the PhD School in Physics, Astrophysics and Applied Physics, of the "Aldo Pontremoli" Physics Department at the State University of Milano (Italy). Each item was designed specifically for this test, and none were taken from existing materials or literature. The questionnaire underwent validation by teachers from the Radioactivity sections of the Department, who selected questions aimed at ensuring the adequacy of the requests considering the sample to which the test was addressed. The teachers of the Physics Didactics section validated the questionnaire, deeming it suitable as a cognitive tool. Finally, a pre-test was carried out on a small sample of students to verify the text comprehensibility and to check the working times, which in fact proved to be excessive and which were reduced by a third compared to what was initially estimated (Borsboom, 2004). A validation of the test was performed by calculating the p-value with reference to the acceptability value S (Fraser, 2019). A p-value of 0.051 was obtained, which for alpha=5% attests to a good choice of the sample and validates the test. A further validation test was carried out using the control questions, particularly those referring to narrative contents, i.e., those relating to   rays and the definition of isotope. For each of these two pairs of data, Cronbach's   was evaluated, providing high values (0.78 and 0.80, respectively) for the numerically more significant group, i.e., group BE (Maul, 2017). For the data of each subset (the two university groups and the three high schools), we considered the frequency with which students provided the same answer to both questions.

Denoting X as one of the four possible answers associated with a question, the expected value for the probability of randomly obtaining the same answer in the pair of items with the same question P(X|X) is $(1/4)^2 = 0.25$. The frequency found in the test aimed at the same sample instead gave the results shown in Table 3. The values found confirm that the answers to this set of pairs of questions were not randomly assigned (Walters, 2021).

Item	Group I	Group II	Liceo I	Liceo II	Liceo III
Isotope	0,87	0,89	0,91	0,80	0,80
γ rays	0,94	0,87	0,89	0,92	0,89
neutrino	0,79	0,76	0,96	0,80	0,82

Table 3: Percentage values of the coincidences in the responses to the control items

2.4 The global sample

The global sample, including final-year high school and university students, consisted of 316 subjects, of whom only 4 were outside the age range of 17-20. There is a slight prevalence of cis-male gender (55%) over cis-female (42%). The transgender component (1%) and those who did not explicitly state their gender choice (2%) represent a small portion of the sample

The university sample

The university sample consists of 171 students and is heterogeneous in terms of social and territorial origin, as well as gender composition (53% cis-male, 44% cis-female, 3% prefer not to declare gender). In group PH, there is a clear majority of cis-male (63%) over cis-female (31%) students, while in group BE there is a slight majority of cis-female (56%) over cis-male (43%) students (Tab. 4).

Group	Cis-female	Cis-male	Trans-gender	No answer
university	44%	53%	-	3%
PH	31%	63%	-	6%
BE	56%	43%	-	1%

Table 4: Gender distribution in the global university sample and in two different groups

The students range in age from 18 to 20 and are therefore homogeneous by age. Their previous school experiences are diverse, but primarily from high schools (Table 5). Only 1% of students have gained previous school experience abroad. Undergraduate students have not taken any nuclear physics courses since their enrollment, and the sample was chosen precisely for this reason. At the same time, due to the composition of STEM students, the group represents a qualified sample.

Group	Humanities High School	Traditional Scientific Curriculum (TSC)	Applied Scientific Curriculum (ASC)	Technical Institute (scientific course)	Technical Institute (not scientific course)	Professional Institute	Other Schools
University	10%	54%	22%	8%	3%	-	4%
PH	17%	43%	20%	11%	2%	-	7%
BE	4%	66%	24%	2%	3%	-	1%

Table 5: Composition of the sample in relation to the address of the high schools of origin. Students coming from TSC+ ASC are the main basin of provenance: they made up the 90% of the BE group of them while the provenance for PH group is a little more heterogeneous

The high school sample.

The high school sample, consisting of 145 students, is balanced in terms of age (94% are under the age of 19) and gender composition (60% cis-male, 38% cis-female, 1% transgender, 1% did not communicate gender), with a slight predominance of cis-male gender. This is largely due to liceo II, which developed from a previous technical institute that has traditionally had a larger number of male students in Italy (Table 6). The sample is homogeneous in terms of territorial origin, characterized by low mobility within institutes. 95% of high school students attended the final three-year course of study in the same institution and in the same class, with only 1% of pupils coming from other institutes.

Scientific curriculum	Cis-female	Cis-male	Trans-gender	No answer
All the schools	38%	60%	1%	1%
Liceo I	46%	51%	3%	-
Liceo II	24%	76%	-	-
Liceo III	41%	57%	-	2%

Table 6: Gender distribution in the global scientific curriculum sample and in three different high schools

The territory of the high schools is characterized by high BES ("Benessere Equo e Sostenibile", that is "Equitable and Sustainable Wellbeing") indicators, almost all higher than those of the region to which they belong and the national averages (ISTAT). The institutes analyzed in the standardized tests in mathematics (INVALSI 21/22) are placed in a high range: the results of the fifth year, compared to institutes with similar ESCS (socio-economic and cultural context), are higher than the regional, macro-territorial, and national averages.

3. Results

3.1 The global sample

To get a general overview, the distribution of the score obtained by the students of the global sample is represented in Figure 2. The average value is 12.68, just below the acceptability threshold S. This is further proof of the validity of the questionnaire, stating that the expected value for a non-trained population is 13. The data shape clearly shows a bimodal distribution with two relative maxima (11 and 13). This can be attributed to the sample composition: high school and university groups.

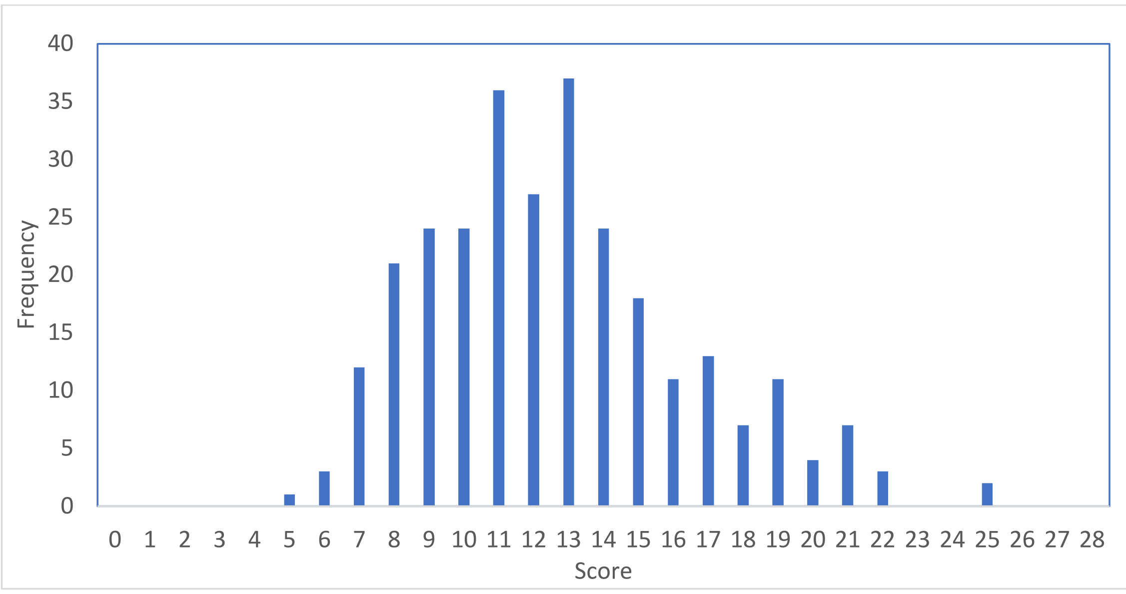

Figure 2: Frequency relative to the different score ranges (orange) over the full population, mean value 12,68

The university sample

Within the university sample, significant differences emerged in the two groups tested, PH and BE (Figure 3). The average value is 13.08, just above the acceptability threshold S. This is further proof of the validity of the questionnaire, stating that the expected value for a non-trained population is 13. The mean values of the two populations are 13.67 (PH group) and 12.20 (BE group) respectively.

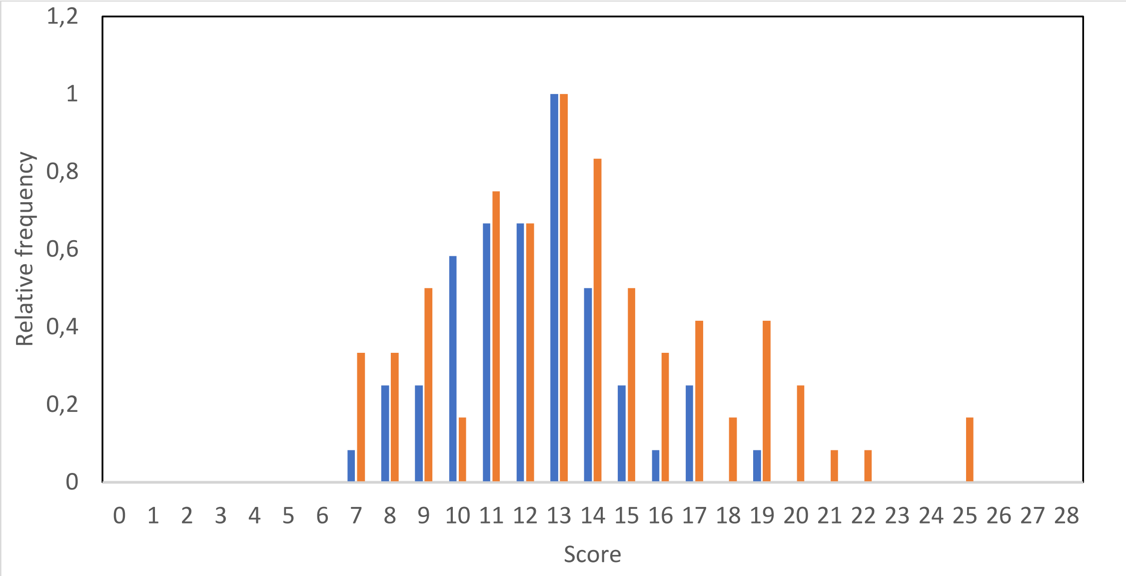

Figure 3: Normalized frequency relative to the different score ranges for groups PH (orange, mean value 13,67) and BE (blue, mean value 12,20)

3.3 The high school sample

It is possible to evaluate the mean value of the high school sample as equal to 12.29. The attendance of students in the various score ranges strongly depends on the institute (Figure 4).

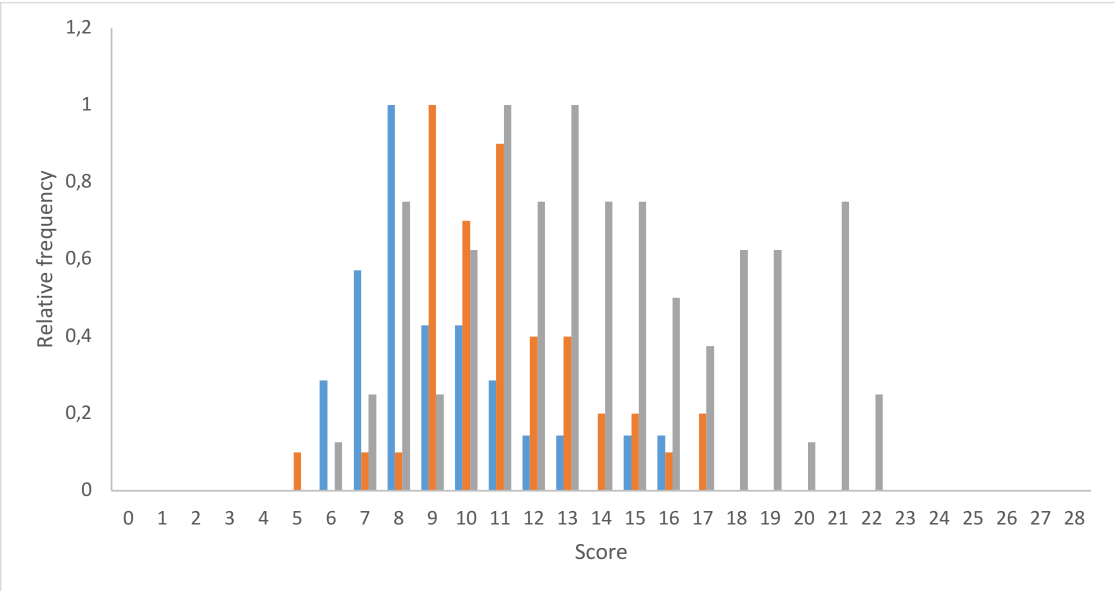

Figure 4: Normalized frequency relative to the different score ranges for high schools: liceo I (grey, mean value 14,00), liceo II (blue, mean value 9,24), liceo III (orange, mean value 11,07)

The average values for the three institutes are: 14.00 for liceo I, clearly higher than the acceptability level S; 9.24 for liceo II and 11.07 for liceo III, both below S. By comparing the trends for the two samples, it can be observed that the frequency with which the score is distributed has a higher maximum for the university sample (Figure 5).

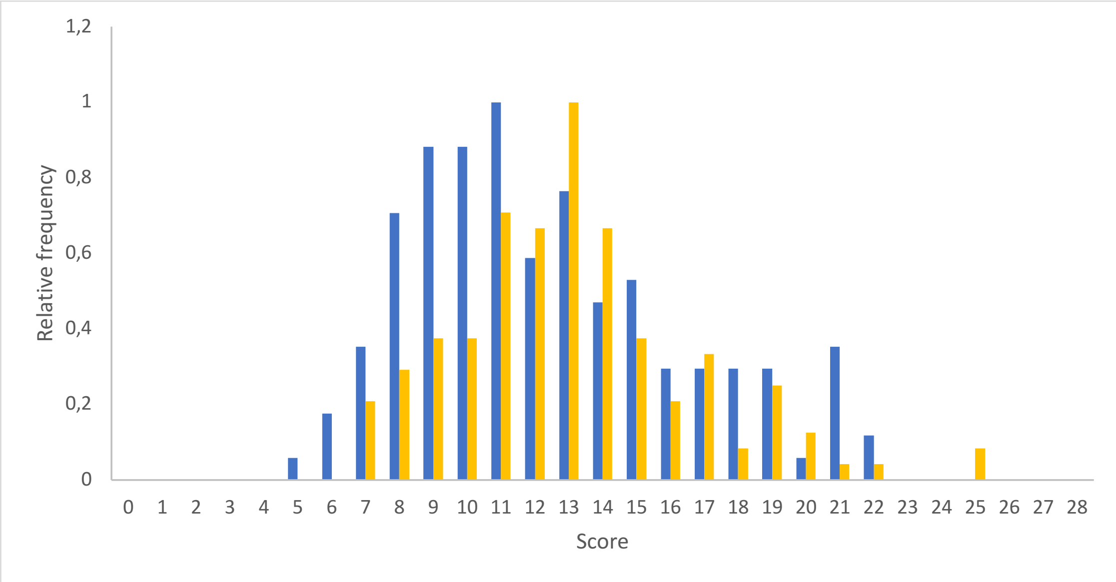

Figure 5: Normalized frequency relative to the different score ranges: high schools (blue, mean value 12,29), university (yellow, mean value 13,08)

The influence of high school teaching on the score

For the two samples (university and high school), the incidence of the number of hours of nuclear physics administered in the high school course on the score obtained by the subjects in the sample was evaluated (Figure 6). The trends of the score as a function of the number of hours of nuclear physics tackled show a substantially similar trend in the two cases

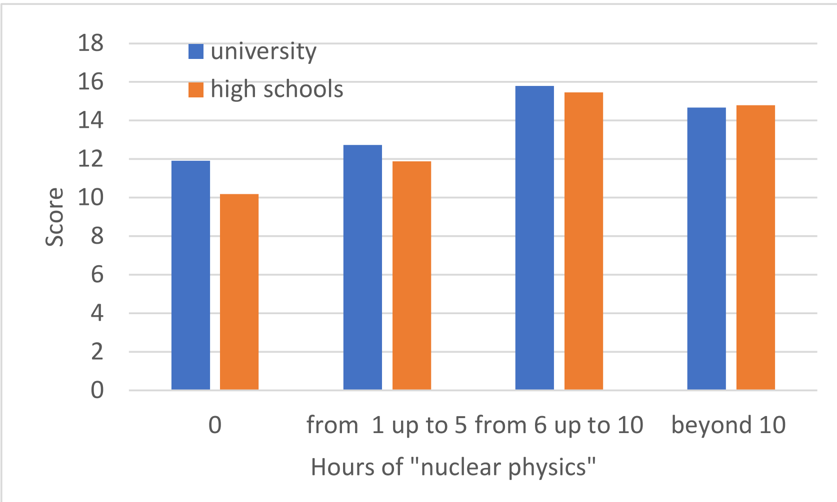

Figure 6: Distribution of the test score obtained according to the teaching hours of nuclear physics in the high school course, global university sample (blue), global high school sample (orange)

The students of the university sample coming from the scientific high school, both traditional cv and applied science cv, obtained average scores higher in group PH than those in group BE (Table 7).

	Global sample	Students TSC+ASC	Students TSC	Students ASC
av. score group PH	13,67	14,34	14,42	14,18
av. score group BE	12,20	12,12	12,19	11,95

Table 7: Average scores correlated to the high schools of origin

The table 7 shows that the origin of the scientific high school, predominant in both courses (63% PH, 90% BE), is discriminating only for students of the PH course.

3.5 The incidence of gender

In the university sample, the gender difference does not influence the score obtained, except for group I, even if it is not significant (Table 8).

	Global sample (av. score)	Cis-feminine	Cis-masculine
av. score group PH	13,67	-7,0%	+5,0%
av. score group BE	12,20	+0,2%	-0,8%

Table 8: Variation in average scores related to gender difference. The data relating to students who did not communicate the gender (numerically irrelevant data) were not considered

As for the groups of university students, also for the sample of high school students the gender difference has no significant influence on the data (Table 9), even if in the three groups between the average results of the students declared cis-masculine and cis-feminine there is a non-negligible difference in some cases.

	Global sample (av. score)	Cis-feminine	Cis-masculine
av. score liceo I	14,00	-2,0%	+0,2%
av. score liceo II	9,24	-11,1%	+4,0%
av. score liceo III	11,07	-7,4%	+5,2%

Table 9: Average scores related to gender difference. The data relating to transgender students or students who did not communicate their gender were not considered (numerically irrelevant data)

4. Discussion

The survey examined two student groups: high school seniors and first-year STEM university students. Results indicate an average preparedness in nuclear physics slightly below the acceptable threshold (mean = 12.68, p-value = 0.501), suggesting only a basic grasp of the subject (Figure 2). While the university sample achieved a higher average score of 13.08, two distinct trends emerged. Students in Biological Engineering (BE) scored below average (12.20) with a normal distribution, while those in Physics (PH) scored above the threshold (13.67) but with no clear distribution pattern. This discrepancy in the PH group stems from two outlier groups with scores significantly above and below the average. Therefore, while the PH cohort demonstrates greater overall preparedness in nuclear physics compared to BE students, it also exhibits greater heterogeneity, encompassing both highly prepared and poorly prepared individuals.

Regarding the academic background, the majority of university students originated from scientific high schools (63% PH, 90% BE). However, this factor significantly impacted test scores only for PH students, who outperformed their group average (14.34 vs. 13.67). Conversely, BE students from scientific high schools showed no significant deviation from their group average, likely due to the limited number of students from other academic backgrounds. This suggests that a specialized STEM program like PH attracts better-prepared students, even within their preferred academic track (scientific high school). The high school sample, comprising schools recognized for strong science programs and lacking contextual specificity, displayed significant heterogeneity in test scores. Despite an average score below the acceptable threshold (12.29), individual school averages varied greatly, with two schools scoring significantly lower (9.24 and 11.07) and one achieving a high score (14.00). This disparity highlights the variability in educational approaches among these schools, indicating a lack of consistency in science curriculum development. Finally, both samples were analyzed for a correlation between test scores and hours dedicated to nuclear physics in high school. 54% of university students reported no prior exposure to nuclear physics, resulting in a below-threshold average score (12.08). Conversely, even minimal exposure (1-5 hours) led to slightly higher scores (12.75), while 6-10 hours yielded significantly higher scores (15.80). Interestingly, exceeding 10 hours resulted in a slight score decrease (14.67) (Figure 6).

This finding supports the notion that understanding basic nuclear phenomena and their applications requires a moderate, rather than extensive, amount of instruction. The lack of a linear relationship between teaching hours and scores suggests that excessive instruction may not translate to improved comprehension. One possible explanation is that "nuclear physics" instruction exceeding 10 hours may have been incorporated into non-scientific subjects (e.g., literature, philosophy, history).

A similar trend emerged among high school students (Figure 6), with one school dedicating significant physics class time to nuclear physics, while others offered limited instruction often integrated into other disciplines, not always scientific. Specifically, in two schools (II and III), most nuclear physics instruction occurred during natural sciences (16% school II, 23% school III) or non-scientific subjects (50% school II, 52% school III), potentially explaining the score discrepancies between schools (Figure 4).

Comparing university and high school samples (Figure 5) reveals a higher score trend among university students, attributable to two factors. Firstly, limited and often non-scientific nuclear physics instruction in some high schools may have hindered adequate preparation. Secondly, students entering STEM programs, particularly specialized programs like PH, tend to possess stronger baseline preparation compared to their high school counterparts (Figure 3). Lastly gender representation within the sample was relatively balanced, with no significant difference between cis-male (55%) and cis-female (42%) participants. Transgender and unspecified gender identities constituted a very small percentage. Gender did not significantly impact overall scores.

However, notable gender disparities emerged within the PH student group (63% cis-male, 31% cis-female) and one high school (76% cis-male, 24% cis-female). In both cases, cis-female students scored significantly lower than their group averages (-7% for PH, -11% for the high school), while cis-male students scored significantly higher (+5% PH, +4% high school). This finding suggests that a significant gender gap in these specific instances may disadvantage cis-female students.

Nonetheless, it is important to note that in Italy, both high school and university segments are highly inclusive by gender, unlike in other international educational contexts (Eurostat; The Royal Society 2014; Higgins, 2015).

5. Conclusions

The survey examined two student groups of final year high school and first-year STEM university in northern Italy. Results indicate an average preparedness in nuclear physics slightly below the acceptable threshold established by the authors. The observed trends in nuclear physics preparedness appear solely attributable to prior instruction in the subject. The high socio-economic background of participating students, coupled with the strong performance of tested high schools in standardized science exams, effectively eliminates socio-economic and school-level factors as influential variables. Even if gender disparities emerged through the score analysis it is important to note that both Italian high schools and universities demonstrate high levels of gender inclusivity compared to other international educational contexts.

The results on teaching activity confirms a common perception: understanding basic nuclear phenomena and their applications or research fields does not require extensive teaching hours. An interesting finding is the lack of a linear relationship between specific teaching hours and the scores obtained. An excessive increase in hours does not correlate with higher scores. An explanation proposed by the authors is that when a large number of hours are formally dedicated to "nuclear physics," they may not all be in strictly scientific subjects.

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Supplementary materials, textbooks in use.

For the most widespread nationally adopted texts, the teaching units of the texts were considered:

U. Amaldi, *Nuovo Amaldi per i licei scientifici. Blu*, Zanichelli
J. Cutnell, *Fisica di Cutnell e Johnson*, Zanichelli
J. S. Walker, *La fisica di Walker*, Pearson
G. Ruffo, Lezioni di fisica, Zanichelli
S. Fabbri, *F come fisica*, Sei
A. Caforio, *Fisica*, Le Monnier

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Ethical statement

This research has been approved by the ethical committee of the University

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