

# SECURING FRESHMEN'S LEARNING THROUGH A PHYSICS REFRESHER COURSE: A BREAKTHROUGH EXPERIENCE AT POLITECNICO DI MILANO

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## Abstract

Nowadays, an academic institution faces the challenge of a not negligible number of undergraduates who drop out. To organise welcome sessions for first-year students appears to be effective in increasing their persistence.

For several years Politecnico di Milano has provided a Physics refresher course to its new freshmen, which is part of a much broader pedagogical project consisting in offering a blended course which integrates this face-to-face activity with Massive Open Online Courses (MOOCs), delivered through Politecnico di Milano MOOCs portal. Held in September and ending before the beginning of the students' academic programme, this two-week course focuses on classical Physics. Freshmen are arranged in different sections depending on their own free choice.

In the 2018 edition of this Physics refresher course an ad hoc multiple-choice test was administered to the participants through the online portal Socrative during the first lesson. Besides fostering a renewed interest in this discipline, this test was intended by us as a means that would enable the teacher to evaluate the students' level of understanding rather than their knowledge in basic Physics and would allow for the freshmen's self-assessment. Considering the positive results of BYOD (Bring Your Own Device) strategy, the students were highly encouraged to use their own electronic devices to take the multiple-choice test.

In order to evaluate the effectiveness of the Physics refresher course, the students who got involved in the test and took the classes were monitored closely with relation to their findings in the undergraduate basic Physics course, which they attended during their first academic year. On the one hand, the average score achieved by these students is higher than the mark attained by the overall freshmen who attended a university Physics course at Politecnico di Milano. On the other hand, also their success rate is higher.

On balance, not only does the Physics refresher course appear to be effective in increasing the new freshmen initial level of knowledge in Physics, but at the same time it is likely to increase the attentiveness to this discipline.

Keywords: Welcome session, Physics refresher course, Higher education, MOOCs, BYOD

## 1 INTRODUCTION

Although traditional lectures appear to be at times inadequate to meet completely learners' needs [1] and the efficacy of a highly participatory approach to teaching and learning has been pointed out [2, 3, 4, 5], traditional lessons are still widely employed in the context of higher education [6, 7]. Nevertheless, over the years non-attendance at university lectures has become an increasingly common practice among the students [8, 9] and this conduct risks being extremely hazardous on

account of the proven link between lecture attendance and subsequent academic performance [10]. Notwithstanding that no research suggests that absenteeism leads inevitably to academic failure and factors like individual student competencies, learning strategies and personality play undeniably a significant role, a correlation has been highlighted between lesson attendance and both examination performance [11] and reduction of undergraduates who abandon their course of study [12].

Furthermore, it is worth to emphasise that freshmen are not a *tabula rasa* at the beginning of their academic carrier. For instance, in the context of Physics teaching, learners enrolled in a scientific programme like engineering, science, chemistry and biology may generally reveal a good amount of misconceptions on a broad spectrum of Physics topics [13, 14]. Actually, these erroneous interpretative schemas and viewpoints, built up over their previous educational path along with life experiences, are further elements which may lead to unsatisfactory academic achievement as well as dropouts.

With relation to these issues, to organise welcome sessions for first-year students appears to be effective in increasing their persistence [15]. In accordance with this approach Politecnico di Milano has provided a Physics refresher course to its new freshmen for several years, which is part of a much broader pedagogical project consisting in offering a blended course that integrates this face-to-face activity with Massive Open Online Courses (MOOCs) delivered through Politecnico di Milano MOOCs portal [16,17] (<http://www.pok.polimi.it>).

The aim of our research is to explore the effectiveness of the 2018 edition of this Physics refresher course in relation to both the freshmen results in the undergraduate basic Physics course, which they attended during their first academic year, and the reduction of the possible dropouts. Indeed, to sail through their Physics exams while keeping to a tight timetable is often problematic and possible failures may result in the freshmen's disengagement and frustration, which could lead them to drop out.

Finally, it is worth to emphasise some original characteristics of our study. On the one hand, an impressive number of both academic basic Physics courses and students were involved, 10 and 2350 respectively. On the other hand, the effectiveness of this Physics refresher course was investigated with specific reference to the type of high school attended by students.

## 2 METHODOLOGY

Starting on the first days of September 2018, the Physics refresher course - 2018 edition - was offered by Politecnico di Milano to all its freshmen. Ending before the start of the students' academic programme, this two-week course was focused on classical Physics, with specific reference to Mechanics, Thermodynamics and Electromagnetism. It consisted in eight lessons each one lasting for four hours. The participants were arranged in ten different sections of several sizes depending on the students' own free choice. Five groups were hosted by "Milano Leonardo" campus, three sections by the "Milano Bovisa" headquarters while "Lecco" and "Piacenza" campuses were home to one group each. Every section had a tutor; the ten instructors involved in our research (six women and four men) were different from each other in terms of cultural background, age and teaching experience.

The 670 freshmen enrolled in this course had attended different types of Italian high schools, even though 70% had graduated from Liceo scientifico (LS), an Italian scientific senior secondary school. About 14% of the students had attended Istituto tecnico (IT), a technical senior high school and around 12% had graduated from Liceo linguistico (LL), Liceo classico (LC) and Liceo artistico (LA), which are senior secondary schools where pupils are required to develop a deeper understanding of modern foreign languages, classical studies, and arts respectively. Table 1 and figure 1 synthesise some data related to these students.

*Table 1. Number of freshmen enrolled in the 2018 Physics refresher course with specific reference to the type of Italian high school attended by the students.*

|                                   | LS  | LL | LC | LA | IT | Other | Total |
|-----------------------------------|-----|----|----|----|----|-------|-------|
| <b>Enrolled freshmen (number)</b> | 469 | 18 | 59 | 5  | 96 | 23    | 670   |

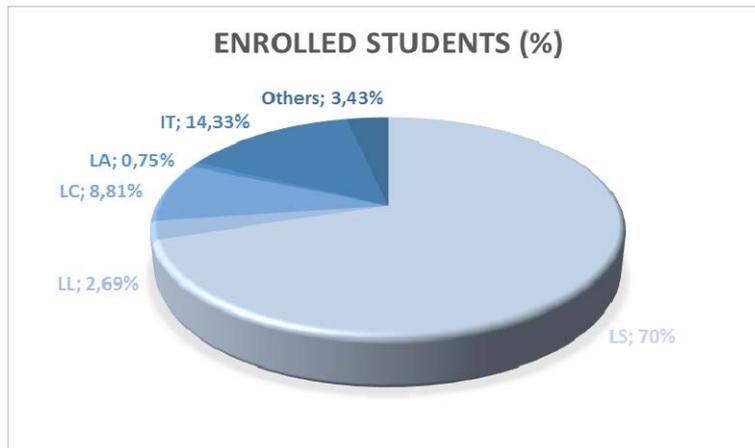


Figure 1. Percentage of freshmen enrolled in the Physics refresher course with specific reference to the type of Italian high school attended by the students.

Despite the fact that the freshmen who actually attended our Physics refresher course were 238, it is worth to highlight that, in terms of type of high school attended, the distribution of the above mentioned percentages follows the same pattern as the distribution of the entire cohort of freshmen enrolled at Politecnico di Milano in 2018. Table 2 and figure 2 show some data related to these participants.

Table 2. Data related to the different sections of the Physics refresher course involved in the research with specific reference to the type of Italian high school attended by freshmen.

| Section | Campus          | Attending students | LS    | LL    | LC    | LA     | IT    | Other | Total attending students |
|---------|-----------------|--------------------|-------|-------|-------|--------|-------|-------|--------------------------|
| 1       | Milano Leonardo | Number             | 11    | 1     | 5     | 0      | 1     | 1     | 19                       |
|         |                 | Percentage (%)     | 57.89 | 5.26  | 26.32 | 0.00   | 5.26  | 5.26  | 100.00                   |
| 2       | Milano Leonardo | Number             | 4     | 1     | 0     | 0      | 4     | 0     | 9                        |
|         |                 | Percentage (%)     | 44.44 | 11.11 | 0.00  | 0.00   | 44.44 | 0     | 100.00                   |
| 3       | Milano Leonardo | Number             | 17    | 0     | 4     | 1      | 5     | 1     | 28                       |
|         |                 | Percentage (%)     | 60.71 | 0.00  | 14.29 | 0.0004 | 17.86 | 3.57  | 100.00                   |
| 4       | Milano Leonardo | Number             | 15    | 0     | 1     | 0      | 1     | 0     | 17                       |
|         |                 | Percentage (%)     | 88.24 | 0.00  | 5.88  | 0.00   | 5.88  | 0.00  | 100.00                   |
| 5       | Milano Leonardo | Number             | 6     | 0     | 1     | 0      | 3     | 1     | 11                       |
|         |                 | Percentage (%)     | 54.55 | 0.00  | 9.09  | 0.00   | 27.27 | 9.09  | 100.00                   |
| 6       | Milano Bovisa   | Number             | 30    | 1     | 4     | 0      | 6     | 2     | 43                       |
|         |                 | Percentage (%)     | 69.77 | 2.33  | 9.30  | 0.00   | 13.95 | 4.65  | 100.00                   |
| 7       | Milano Bovisa   | Number             | 48    | 3     | 6     | 0      | 12    | 2     | 71                       |
|         |                 | Percentage (%)     | 67.61 | 4.23  | 8.45  | 0.00   | 16.90 | 2.82  | 100.00                   |
| 8       | Milano Bovisa   | Number             | 25    | 3     | 2     | 0      | 3     | 1     | 34                       |
|         |                 | Percentage (%)     | 73.53 | 8.82  | 5.88  | 0.00   | 8.82  | 2.94  | 100.00                   |
| 9       | Lecco           | Number             | 3     | 0     | 0     | 0      | 0     | 0     | 3                        |

|    |          |                |        |      |      |      |      |      |        |
|----|----------|----------------|--------|------|------|------|------|------|--------|
|    |          | Percentage (%) | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |
| 10 | Piacenza | Number         | 3      | 0    | 0    | 0    | 0    | 0    | 3      |
|    |          | Percentage (%) | 100.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 100.00 |

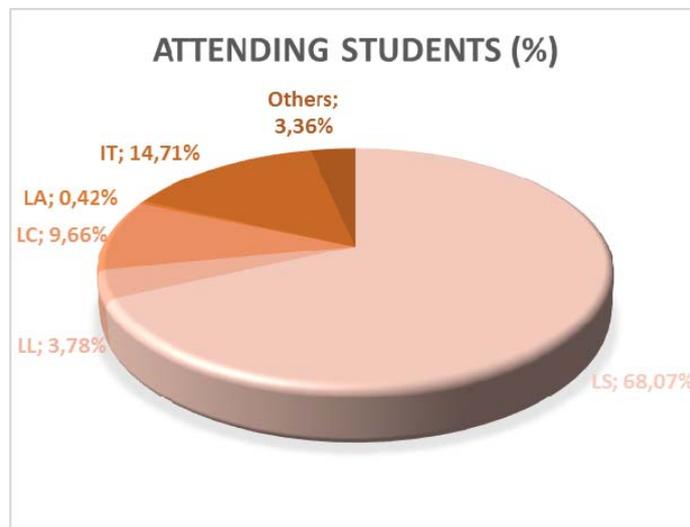


Figure 2. Percentage of freshmen who took part in the Physics refresher course with specific reference to the type of Italian high school attended by the students.

During the first and the last lesson of the Physics refresher course, an identical ad hoc multiple-choice test was administered to the first-year university students. Submitted through the online portal Socrative [18], this test enabled the tutors to evaluate the students' level of understanding rather than their knowledge in basic Physics and allowed for the freshmen's self-assessment. Furthermore, it was meant to foster a more and more renewed interest in this discipline. Considering the positive results of the BYOD (Bring Your Own Device) strategy [19], the students were encouraged to use their own smartphones, notebooks and tablets alike to take the multiple-choice test. This test consisted of 16 multiple choice quizzes, 6 based on Mechanics topics, 4 on Thermodynamics subjects and 6 on Electromagnetism themes. Each multiple-choice question had four alternative answers, of which only one was correct. The time allotted to each quiz, 90 seconds, and the order of the questions were previously established, consequently the students could not manage their time, nor the order to answer the quizzes.

Moreover, during the course the students took further periodical tests based on multiple-choice quizzes whose provision was once more implemented by using the online portal Socrative and by allowing the students to use their own electronic devices. Needless to say, these tests were dissimilar from the initial one.

On balance, the course was organised as a mix of traditional lectures, debates based on a specific Physics problem or educational videos, case studies and online quizzes alike.

Finally, every student enrolled in the Physics refresher course was invited to fill in an online evaluation questionnaire related to the entire pedagogical project offered by Politecnico di Milano, consisting in MOOCs, the Physics refresher course and online quizzes. Needless to say, only the students who really took part in the face-to-face activity, i.e. classroom lectures, could answer the questions related to these lessons. Available to the students from the end of the Physics refresher course, this survey was filled out by 154 first-year university students who had taken part in our educational activity. This questionnaire contained eight questions, each of which had four possible options corresponding to different students' opinions and the answers ranged from 1 (completely useless for learning purposes) to 4 (very useful for learning purposes).

### 3 RESULTS

To evaluate the effectiveness of the Physics refresher course we analysed the freshmen results in their own academic basic Physics course final examination, comparing and contrasting the findings of the students engaged in our refresher course to the outcomes of the first-year university students enrolled in Engineering at Politecnico di Milano.

In order to decrease the number of dropouts, it is desirable that students can pass their Physics final examination before the beginning of their subsequent academic term. As a consequence, we considered that a student passed their Physics exam if and only if the just mentioned condition had been fulfilled.

We considered the results of the freshmen who attended their Physics course during the first term of their academic year, which started around mid September 2018 and terminated by the end of February 2019. Table 3 shows their outcomes in their Physics final examination.

*Table 3. Data about the freshmen results in their Physics final examination at the end of their first academic term related to both students who attended the Physics refresher course and the other first-year university students enrolled in Engineering at Politecnico di Milano in academic year 2018-2019.*

| Freshmen                               | Enrolled in a Physics academic course attended during term I | Passed the examination | Passed (%) | Average mark | Standard deviation |
|--|--|------------------------|------------|--------------|--------------------|
| Attending the Physics refresher course | 87   | 61                     | 70.11      | 24.41        | 3.70               |
| Engineering Politecnico di Milano      | 2350   | 1358                   | 57.79      | 23.77        | 3.61               |

The table reveals that about seven freshmen out of ten passed their own Physics final examination before the beginning of their second academic term if they had attended the Physics refresher course in September 2018. On the contrary, the rate of the overall first-year university students enrolled in Engineering at Politecnico di Milano who achieved this aim was amazingly lower and reached just 58%. However, it is appropriate to point out that the vast majority of freshmen, i.e. 3418, 151 of whom had taken part to the Physics refresher course, attended their academic Physics course during the second term of the academic year 2018-2019.

Moreover, it may be emphasised that the students who had been involved in the previously mentioned Physics refresher course highlighted a significantly better average mark than all other Politecnico di Milano freshmen: 24.41 compared with 23.77.

On the other hand, the already mentioned satisfaction survey allowed us to investigate the students' opinion on the overall Politecnico di Milano welcome session as well as each of its parts. As regards the Physics refresher course, the rate of freshmen who claimed that it was useful to their learning reached 86%. Considering the entire project their judgement was overwhelmingly positive: only 11% evaluated it as far from satisfactory or inadequate. Tables 4 and 5 synthesise data related to these two questions of the survey.

*Table 4. Question number 2 of the satisfaction survey: data about the opinion of the first-year university students on the Politecnico di Milano Physics refresher course (edition 2018).*

| Question 2: Were Physics lectures useful to your learning? |                   |              |      |                    |        |      |
|--|-------------------|--------------|------|--------------------|--------|------|
| Option (score)   | Students (number) | Students (%) | Mean | Standard deviation | Median | Mode |
| Not at all (1)   | 1                 | 0.69         | 3.23 | 0.69               | 3      | 3    |
| Not so useful (2)  | 19                | 13.10        |      |                    |        |      |

|                 |    |       |  |  |  |  |
|-----------------|----|-------|--|--|--|--|
| Useful (3)      | 71 | 48.97 |  |  |  |  |
| Very useful (4) | 54 | 37.24 |  |  |  |  |

Table 5. Question number 8 of the satisfaction survey: data about opinion of the freshmen on the Politecnico di Milano overall 2018 welcome project.

| Question 8: Were the overall welcome activities useful to your learning? |                   |              |      |                    |        |      |
|--|-------------------|--------------|------|--------------------|--------|------|
| Option (score)   | Students (number) | Students (%) | Mean | Standard deviation | Median | Mode |
| Not at all (1)   | 3                 | 2.07         | 3.12 | 0.64               | 3      | 3    |
| Not so useful (2)  | 13                | 8.97         |      |                    |        |      |
| Useful (3)   | 93                | 64.14        |      |                    |        |      |
| Very useful (4)  | 36                | 24.83        |      |                    |        |      |

## 4 CONCLUSIONS

Nowadays, an institution of higher education faces the challenge of a not negligible number of students who drop out or need extra time to conclude their academic career. Politecnico di Milano is no exception. This problem is particularly acute with regard to the new freshmen on account of their inexperience in dealing with the complexity and depth of university studies. However, future first-year university students appear to be conscious of this issue and would like to be helped and supported by their academic institution. This blatantly emerged when analysing the answers given by the prospective freshmen enrolled in the Physics refresher course that was about to start before the beginning of the academic year 2018-2019. To the question: "Why do you wish to attend this course?", almost the totality of students (94%) replied that they wanted to prepare better for the future academic Physics courses.

With relation to this expectation, the evaluation questionnaire highlights that both the Physics refresher course and the overall welcome session were highly valued. Only one freshmen (0.69%) judged the Physics refresher course totally worthless, while nineteen freshmen (13.10%) claimed it to be of little use. On the other hand, only three students (2.07%) considered the overall project as utterly pointless, while thirteen students (8.97%) claimed it was not so fruitful. As a consequence, one could argue that the welcome session is effective in engaging future first-year university students and is likely to increase their attentiveness to Physics. Moreover, the effectiveness of the refresher course emerged clearly when we analysed the findings in the final Physics exams taken by the students who had attended this course. Indeed, the average score achieved by these students (24.41 out of 30) is higher than the mark attained by the overall freshmen who had attended a university Physics course at Politecnico di Milano (23.77 out of 30). It implies that not only does our welcome session meet the expectations of the prospective Politecnico di Milano freshmen, it is at the same time truly effective in increasing their background knowledge in Physics. This result could help to decrease the students' disengagement as well as enhance their self-esteem. In conclusion, the Physics refresher course appears to be able to secure the freshmen's learning and proved itself to be a breakthrough experience.

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