# Integrating MOOCs in Physics preliminary undergraduate education: beyond large size lectures.

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## Abstract

In this paper, the authors discuss the effectiveness of MOOCs as part of a pedagogical strategy aimed at supporting Physics' preliminary undergraduate students in large-size lectures. Our study is based on an experimental activity based on a blended course, which integrated a parallel MOOC delivered through the POK (PoliMi Open Knowledge, http://www.pok.polimi.it), the Politecnico di Milano's MOOC portal. The blended model also delivered face-to-face activities that included intensive technology enhanced learning, like feedback based on clickers. Specifically, we introduce the several elements of the approach (the tutors' pedagogy, the adoption of clickers, the diversity amongst learning groups) and its process of implementation. The findings in this study highlight that the integrated model is effective in terms' of students' learning both for small and large size lectures. More importantly, it was found that the students in large size lectures demonstrated similar or even better performance than students in a small size group. Moreover, the students in all sizes lectures showed higher satisfaction with the MOOCs' against other factors adopted within the learning design.



**Keywords:** MOOC, Physics, Large Size Lectures, Higher Education.


## Introduction

In the context of the modernisation of higher education, the increasing number of students attending massive lectures as well as the connected phenomenon of disengagement, demotivation and finally drop-outs, require urgent intervention (Brown, Calkins, & Siemens, 2012). Crowded lectures lead to less interactions and pedagogical support from teachers, disorientation and troubled access to course activities and resources for learning (Allendoerfer et al., 2016). The counterpart of this situation from the students' side is an intensification of already existing problems in the study method, particularly for those learners at the beginning of their academic experience In fact, the lack of close support and feedback encompasses less ability to regulate learning processes (Allendoerfer et al., 2016; Bettinger & Long, 2016). The impact of this situation is the students' decreasing self-efficacy, low self-esteem, frustration, unmanaged extraneous cognitive load and feelings of isolation that lead to failure at exams or drop-out (Oldfield, Rodwell, Curry, & Marks, 2017).

Moreover, as the numbers of students' increase, the number of drop-outs rise, with an impact on system effectiveness and productivity: high amount of resources devoted to large numbers of students, with final achievements for a small number of students (Lassibille & Navarro Gómez, 2008). According to (Barefoot, 2004), teacher support shape students' performance, their sense of achievement and thus the retention rates. In the same vein, Ulriksen, Madsen, & Holmegaard (2010) explored the literature from 2000-2009 on the motivations for students to drop-out of STEM programmes. These authors explain that drop-outs should be also studied through the conceptions of science teaching as well as the institutional approaches to science teaching, beyond the students' characteristics and their prior scientific skills and knowledge. This situation highlights the need to reformulate learning design within the initial courses preparing to STEM careers. The new designs could encompass innovative, technology enhanced learning methods.

To this regard MOOCs, as special cases of large numbers in courses, have provided effective solutions to support students' study skills and self-regulation (Brita-Paja, Gregorio, Llana, Pareja, & Riesco, 2018). However, MOOCs should not be seen as isolated elements but as strategical components along a pedagogical design aiming at targeting typical problems in large size lectures. In fact, the design should carefully select the combinations of MOOCs and in class activities to promote engaging content, feedback, flexibility and continuity in the learning experience, expected to trigger students' positive response that prevents drop-out in time.

The aim of this paper is to explore the effectiveness of MOOCs in the context of a blended model for large size lectures. The authors introduce a case study on the design, implementation and evaluation of a preparatory Physics course within the Politecnico di Milano (POLIMI), as crucial baseline for further studies in Sciences and Engineering. The authors explain the process of implementation and the impact of a blended approach integrating MOOCs. The several pedagogical factors (MOOCs, active learning, self-assessment and tutor's guidance) are compared in relationship to the group's size (small or large).

## Background

MOOCs have had an impressive coverage in press and social media since Siemens' "educational experiment" in 2008 (Siemens, 2012). They have been viewed as a leverage to renew higher education (Brown et al., 2012; Knox, 2014), and the research community paid attention to the development of practices and research on the phenomenon in several cycles of discussion (Liyanagunawardena, Lundqvist, & Williams, 2015; Raffaghelli, Cucchiara, & Persico, 2015). Indeed, MOOCs' integration as part of undergraduates and post-graduates formal education could leverage quality in higher education (Ghislandi, 2016). Particularly the research on blended models adopting MOOCs is demonstrating its usefulness (Pérez-Sanagustín, Hilliger, Alario-Hoyos, Kloos, & Rayyan, 2017) . Among the topics under analysis, there are frequent attempts to find evidence on the way MOOCs' integration with traditional teaching activities could improve access, support more flexible learning approaches and promote effective learning contributing to modernize pedagogical and business models in higher education (Bozkurt, Ozdamar Keskin, & De Waard, 2016; Ossiannilsson, Altinay, & Altinay, 2016). Moreover, the research carried out on MOOCs has been said to provide evidence to design solutions for well-known pedagogical issues in higher education (Gasevic, Kovanovic, Joksimovic, & Siemens, 2014). In fact, at least three topics could be considered: assessment, prediction and self-paced learning. Regarding the first issue, there are important trends relating videos as massive learning resources (Canessa, Tenze, & Salvatori, 2013; Seaton et al., 2014), automatic assessment (Acosta & Otero, 2014; Glance, Forsey, & Riley, 2013; Lepp et al., 2017; Miranda, Mangione, Orciuoli, Gaeta, & Loia, 2013), self-assessment and peer review (Admiraal, Huisman, & Van de Ven, 2014; Floratos, Guasch, & Espasa, 2015; Kulkarni et al., 2013). With regard to the second topic, the constructs of self-paced, self-determined and self-regulated learning treated interchangeably in spite of diversified theoretical backgrounds, have gained terrain (Chen & Chen, 2014; Cho & Yoo, 2017; Hood, Littlejohn, & Milligan, 2015). Finally, the cross disciplinary issue of prediction in learning has mainly considered the problem of drop-outs, engagement and learning effectiveness throughout data-driven research approaches (Halawa, Greene, & Mitchell, 2014; Jiang, Zhang, & Li, 2015). More recently, Mar-San Agustín et al. (2017) have explored a framework to characterize MOOCs integration into higher education blended approaches. The Hybrid MOOC (HMOOC) framework blends two variables: curricular content alignment (from no to full recognition of MOOCs learning within the career pathway) and institutional support (from minimum to maximum infrastructure, service and teaching support to students' engaged in HMOOCs). In spite of applying the framework to analyse existing cases, the authors point out the need of exploring the impact of the several models resulting from the combinations of the two variables mentioned before.

The typical problems researched in MOOC can be connected straightforwardly with large size lectures: massive delivery of resources that should encompass support to self-organize one's learning paths, less teacher-students interactions, less time to monitor learning progresses through formative and responsive teacher feedback, unfeasible teacher workload in assessment tasks, all situations encompassing the need for more self-regulated students. However, more research on more institutionalized models, analysing the differences between MOOCs in small and large size lectures could encompass more informed practices and continuing innovation. Moreover, transferring these analysis into specific disciplinary fields such as STEM (Science, Math and Technology) learning would lead to acknowledge differential impacts and to tailor learning design (Colvin et al., 2014).

## Method

The authors adopted a case study as research method. Case studies are forms of detailed accounts on a study object (in our case, a university course) in order to uncover emerging phenomena, processes, mechanisms and eventual solutions given by the people engaged in the case (Stake, 1994). Case studies have been used in a number of social science disciplines, and particularly in educational research. Initially case studies were produced by external researchers as observers of ongoing interventions/processes; the more recent trends emphasize the importance of reflective engagement by the case's participants (Yin, 2009).

Our case study describes the process of learning design and a first round of intervention. In this context, we will define "intervention" as the implementation of a blended undergraduate course with the integration of MOOCs. The research questions explored were:

1. Do integrated blended learning designs improve learning?

2. Do integrated blended learning design mitigate the negative effects of learning in large size lectures?
3. Which was the importance of MOOCs in this type of learning learning design?

Firstly, we consider the contextual factors of the case study (institution and course's description). Secondly, we present the experimental intervention carried out (process) and its factors (MOOCs, Active Learning, Self-Assessment, Tutors' guidance). Thirdly, we describe the data analysis instruments (tests and questionnaires) as well as the students' results in terms of learning and opinion on the pedagogical factors.

***The institutional context: Polimi Open Knowledge, a strategic approach to MOOCs delivery***

The MOOCs platform Polimi Open Knowledge (see figure 1 for details) - POK (www.pok.polimi.it) was implemented with the aim of "bridging the gaps", that is, a strategy to suppor the students in their career transitions. The platform was designed by METID, the service of Politecnico di Milano, devoted to e-learning and e-collaboration http://www.metid.polimi.it) on the basis of Open edX.

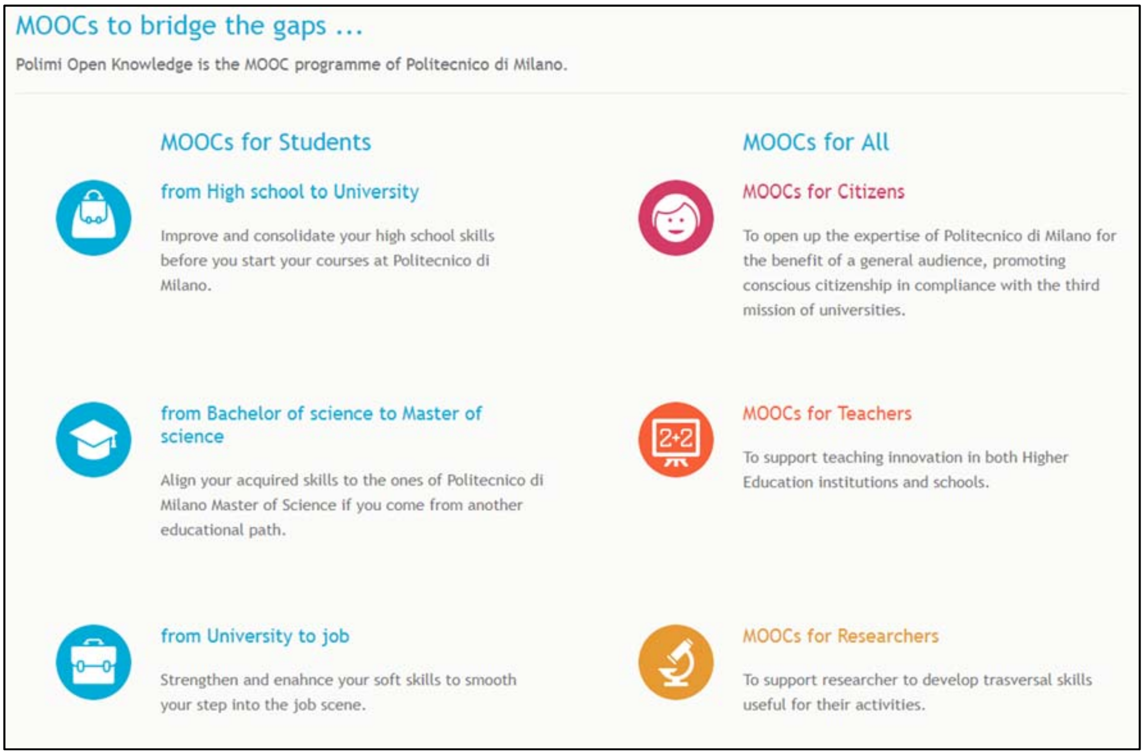


Figure 1 - Polimi Open Knowledge (POK) site

In the following years, the MOOCs platform grew to cover other educational strategies, such as teaching innovation in both higher education institutions and schools, as well as to open up the expertise of Politecnico di Milano for the benefit of a general audience in compliance with the third mission of universities. At present, 25 MOOCs are delivered through POK, more than 45.500 users registered and more than 65.000 are the course registration.

Our case study can be located on the first area of work since the intervention aimed at consolidating the students' STEM skills before starting courses at Politecnico di Milano; from Bachelor of Science to Master of Science, aligning students' skills to the Master of Science of Politecnico di Milano.

***Physics pre-courses: an approach for large size lectures.***

In the above mentioned context, the initial project in the disciplinary area of Physics was aimed at balancing the students' entry skills required for the POLIMI STEM careers. The pre-courses were optional; however, the enrolments increased yearly, with nearly 2000 in the academic year 2016-17.

Due to this large size class setting, since the academic year 2015 and 2016 the pre-course of Physics required a re-design, which entailed the introduction of MOOCs as strategy to support self-study. Moreover, the MOOCs were combined with other pedagogical factors, addressing active learning strategies, which we describe in the following.

***Learning Design: Pedagogical factors***

In the following, we will introduce the main pedagogical factors featuring the experimental intervention in this case study: MOOCs, active learning, self-monitoring and assessment, tutors' guidance.

**Pedagogical Factor 1: MOOCs.** Two separated MOOCs, delivered to a broader audience by the POLIMI, were suggested to the students in order to introduce and accompany in-class activities:

- MOOC I, *Introduction to Experimental Physics: Mechanics, Thermodynamics*.
- MOOC II, *Introduction to Experimental Physics: Electromagnetism, Optics, Modern Physics*.

The MOOCs were carefully prepared by a team of content, educational and multimedia experts (1 coordinator, 8 tutors and 7 multimedia and educational designers). The Physics team devoted time to shorten explanatory sequences, to produce significant experimental examples, case studies, modelled experimental activities as worked examples and other simulations. Storyboards, shooting and final post-editing where lead by the course coordinator to ensure the quality of multimedia resources[1]. The videos introduced virtual lessons with explanations based on demonstrations based on real objects in the lab as well as mathematical expressions, simulating real contexts of experimental physics. The shots were selected to emphasize the teachers' real or virtual demonstrations: frontal when adopting instruments, zenithal when working on mathematical expressions and graphical demonstrations. The video was also enriched with transcriptions, but also labels with key words, the names of the theorems adopted for the demonstration, and forms with the main physical properties (laws, theorems, principles). The videos could be stopped and browsed by the user "on demand". Some 60-90 quizzes for activation and final self-test (relating to the specific video) accompanied the video-sequences.

**Pedagogical Factor 2: Self-Monitoring and Assessment.** Exercises, worked examples on experiments and self-test quizzes ensured a deeper exploration of the concepts taught. The whole approach promoted self-regulated learning, offering flexible pathways of content, exercises and automatized feedback aligning with in-class activities. Moreover, the teachers adopted an open online forum to give continuity to informal, less structured digital communication with the students along the process. The forum was frequently adopted by the students for peer-collaboration and learning.

**Pedagogical Factor 3: Face to Face Active Learning.** The on site activities consisted mainly in short explanations and demonstrations, followed by short specific quizzes, related to the contents taught and delivered via the use of clickers or a Student's Response

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[1] Introduction to Experimental Physics 1: https://www.pok.polimi.it/courses/course-v1:Polimi+FIS101+2017_M7/about

Introduction to Experimental Physics 2: https://www.pok.polimi.it/courses/course-v1:Polimi+FIS102+2017_M7/about

System. In this case, the software adopted was was based SOCRATIVE[2]. The answers given by the students were visualized immediately after the response, supporting tutors to deepen on systematics errors.

After activities in class, the students could come back to the online environment for self-testing and independent study activities.

The Figure 2 illustrates the course' learning design and its pedagogical factors .

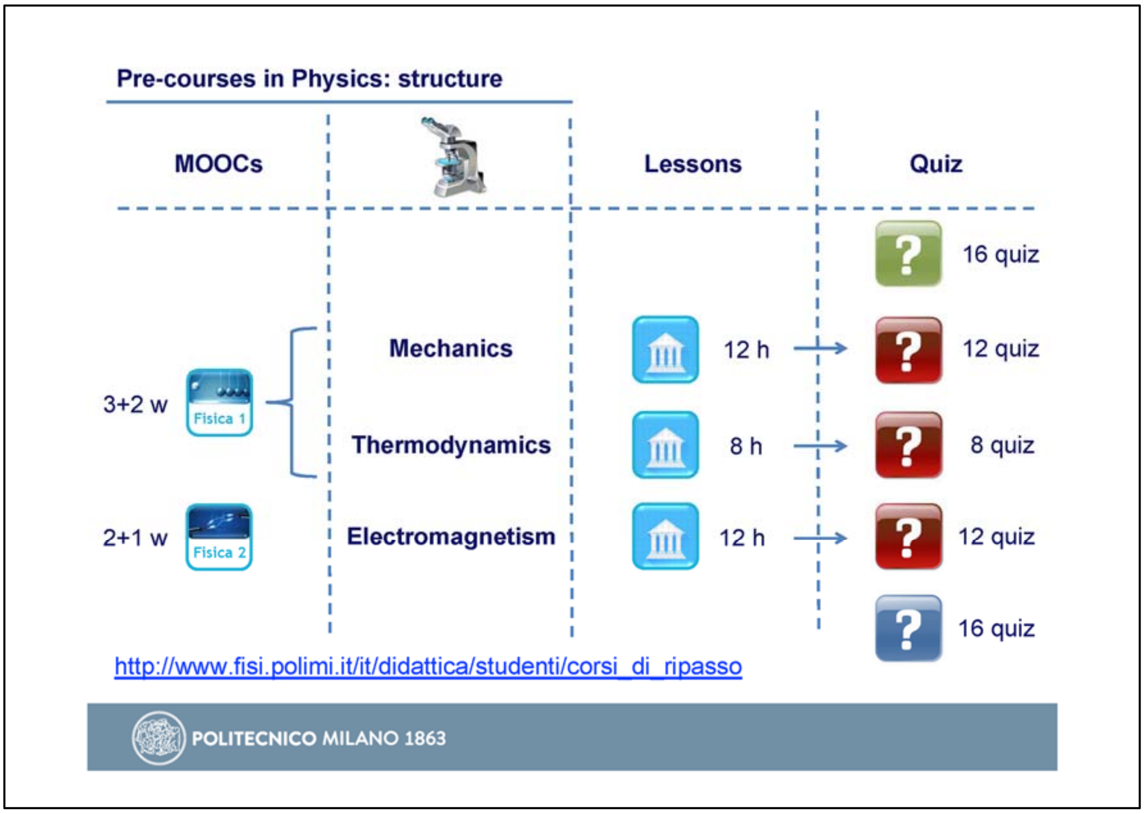


Figure 2 – Course design

**Pedagogical Factor 4: Tutor's Guidance.** Teaching assistants guided students along the course (intervening on both face-to-face and digital sides of the courses). Each tutor was trained in a similar way in order to ensure that the other three pedagogical factors remained stable. However, each tutor showed communicational styles and approaches in supporting the students that added an intervening variable characterized here as "tutor's presence".

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[2] https://www.socrative.com

### *Data collection and analysis*

The participants were divided into 6 groups of several sizes on the basis of the local infrastructures: 3 groups at the "Milano Leonardo" headquarters (211, 104, 90); 2 groups at "Milano Bovisa" headquarters (112,111); 1 small group at the headquarter of "Lecco"(13). This latter small section was used as control section for the variable "class dimension". The participants were randomly assigned to each group.

The data was collected throughout several instruments along the course, in order to inform the overall impact of the intervention, as well as the specific impact of each pedagogical method. The results were compared across the small and large size lectures, in order to make comparisons between two main variables: pedagogical factors (particularly MOOCs) and class dimensions (small or large). All data was collected from September and December 2016, the period of course delivery.

The general impact of the four pedagogical factors integrated across small and large size lectures, was analysed through pre/ post-test approach. The impact was measured in terms of students' knowledge on the course content. This data was collected through tests elaborated by the teaching staff, who calibrated the items' elaboration and distribution according to the theoretical structure of the course. Moreover, an item-analysis was performed and the items deemed too easy or too difficult were eliminated. Along the intervention, considerable loss of paired data due to the impossibility to track every student/unit participation. Therefore, 641 students took the initial assessment test, and 144 students took the final assessment test. Only the mean values for paired values (N = 46) were compared.

For each pedagogical factor, the students' perception of effectiveness and satisfaction was studied through a final survey. A questionnaire with a 1-4 scale studied the levels of agreement with statements relating the perceived effectiveness of the four pedagogical factors, namely: MOOC, Self-Monitoring and Assessment, Face to Face Active Learning, Self-monitoring and self-assessment. The instrument's reliability was analysed through a Cronbach Alpha test (4 subscales, N=196, $\alpha$= .73) reaching an acceptable value of internal consistency.

Only for the specific case of MOOCs, a time series on the enrolments was built in order to observe the general students' engagement with this type of method; moreover, the frequency of access to the digital resources within the MOOC was calculated by analysing the "views" (or visits).

As for the statistical treatment of the data collected, the Student's *t* test was applied to study the overall impact of the integrated design on students' learning across small and large size lectures, for each group. Instead, the analysis of variance one-way ANOVA test was applied to see the effects of each pedagogical factor.

For all the analyses, the Open Source software R was used. All open datasets and code adopted can be found on ResearchGate[3].

**Results**

The number of enrolled students in the "Physics' MOOCs FIS01-2" remained stable along the three years of pre-course delivery, as it is showed in Figure 3, with peaks at the beginning of academic years.

Total enrolled students since June 2016 to March 2017 were 9.213 units for Physics 1 and 6.114 for Physics 2, with a mean of 576 and of 382 enrolled students for pre-course respectively, for 17 editions.

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[3] Project "Getting Started with Physics: preliminary undergraduate strategies" - https://www.researchgate.net/project/Getting-started-with-Physics-preliminary-undergraduated-strategies

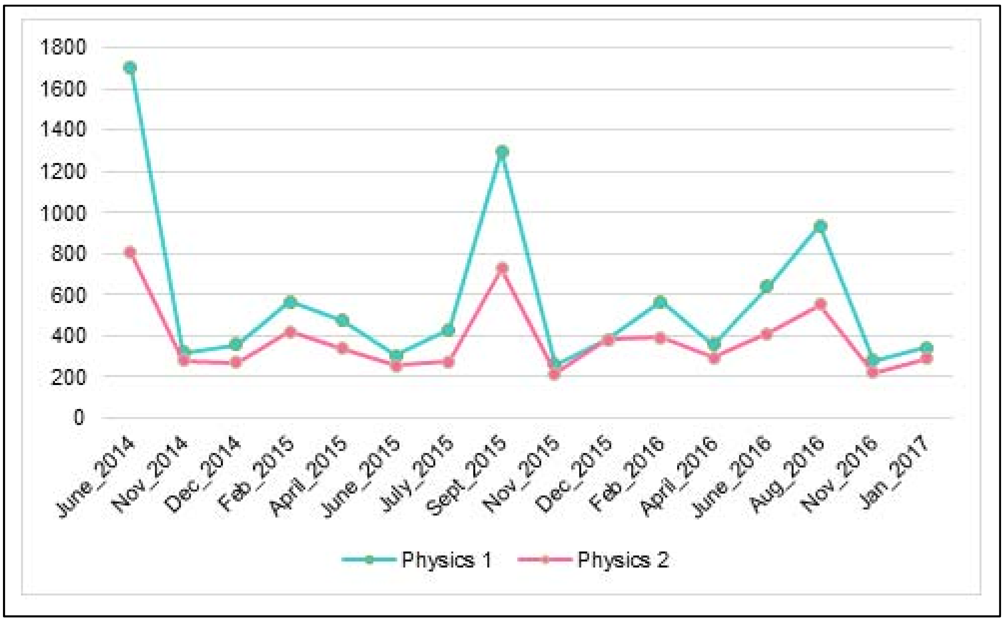


Figure 3 - Enrolled students at the Physics Pre-courses

With regard to the first pedagogical factors, that is, MOOCs, the single videos, since their publication, got 199.290 views, and the second MOOC, 206.764 views. These views imply that for every edition of FIS01, there were 12.455 views, and 22 views per student; which for FIS02 became 12.922 views/edition and 34 views/ student. These data is rich and complex and should be further analysed, but in this case, it is pointing out a good level of engagement with the MOOCs offered.

Moving to the overall impact of the integrated factors, the Student's *t* test was applied to test the hypothesis that the integrated factors would have an overall positive impact on students' learning. The students in all groups showed significant higher scores in the final assessments (post-test) than in the initial pre-test (Pre-test mean = 4.01, Post-test mean = 5.97, t = 9.78, df = 783, p = <.001), rejecting the null hypothesis that the overall pre-courses integrated did not have any effect on students' learning as assessed by tests. This general result and the synthesis of achievements for each separated group are reported in Table 1.

| | | Group1 | Group2 | Group3 | Group4 | Group5 | Group6 |
|---|---|---|---|---|---|---|---|
| Pre-test | N | 211 | 104 | 90 | 112 | 111 | 13 |
| | Mean | 4.03 | 3.72 | 3.57 | 4.33 | 4.30 | 3.63 |
| | SD | 2.92 | 1.68 | 1.84 | 1.46 | 1.27 | 1.59 |
| Post-test | N | 36 | 9 | 42 | 15 | 28 | 14 |
| | Mean | 6.66 | 5.03 | 4.72 | 5.31 | 7.21 | 6.72 |
| | SD | 2.83 | 1.78 | 2.09 | 1.36 | 2.06 | 1.58 |
| Effect size | | 0.90 | 0.78 | 0.60 | 0.68 | 1.99 | 1.95 |
| Student's t test | t | 5.00 | 2.24 | 3.20 | 2.46 | 9.43 | 5.05 |
| | p-value | <0.001 | 0.028 | 0.002 | 0.015 | <0.001 | <0.001 |

Table 1 – Synthesis of statistical comparisons between the mean values of pre and post-tests within each group

As we observe in table 1, all groups showed significant higher scores in the post-tests in comparison with pre-tests, independently of the diversified conditions (small or large classes). However, the observed effect sizes add some relevant information to interpret our results. In fact, there were three groups (2, 3, 4) where the effect sizes could be considered from medium to large (i.e. between 0.5 and 0.8); for the remaining three groups (1, 5, 6) the effect sizes had to be considered large. Particularly groups 5 and 6 (with the highest effect sizes, above 1.9 and therefore extremely large) were diversified in dimension: there was a very small group with only 13 students, as well as one of the initially largest groups (111). This is clearly emphasizing the fact that the lecture size did not specifically influence the students' performance, and the whole approach was offering pedagogical factors having impact on the learning effectiveness. We should consider in any case the high rate of attrition (82% in the Group1 and 91% in the Group2), which could encompass in any case small final numbers of students in interaction with the tutors.

As for the specific impact of each pedagogical factor, the table 2 shows the results of analysis of variance (one-way ANOVA) applied to compare the different group's reactions to each of the pedagogical factors.

Across the four pedagogical factors within the learning design, we observe that the MOOCs impacted well, with the highest mean scores indicating satisfaction (in average 3.33 on a scale 1-4). Moreover, the main effect of MOOCs was not significant across the groups compared with $F(5,192) =. 98$, $p= >.05$, n.s., which shows an homogeneous impact of MOOCs across groups, independently of their size.

The active learning in class, as well as the tutor's approach to teaching, were also evaluated positively by the students (an average of 3.19 for the first elements and 3.23 for the second, slightly lower perceived effectiveness than for MOOCs). However, these two factors were sensible to the class-size effect. The main effect of active learning was significant across the six groups with $F(5,266) = 9.41$, $p= <.001$; in the same vein, the main effect of the tutor's approach was significant across the six groups with $F(5,266) = 15.26$, $p= <.001$. This issue could be interpreted in terms of the relevance (as perceived by the students) of teaching strategies to lead large size lectures. However, the different effects could be also due other intervening variables relating the tutor's style and expertise. Finally, the self-assessment activities through quizzes were the least valued (in average 2.59). However, the main effect of this pedagogical factor was not significant across the six groups $F(5,266) =.45$, $p= >.05$, n.s. We could infer here that the students perceived the pedagogical factor as less effective and relevant.

| | | Group1 | Group2 | Group3 | Group4 | Group5 | Group6 | F | p-value |
|---|---|---|---|---|---|---|---|---|---|
| MOOCs | N | 62 | 17 | 51 | 27 | 30 | 11 | | |
| | Mean | 3.13 | 3.27 | 3.36 | 3.37 | 3.39 | 3.47 | .98 | .43 |
| Active Learning | N | 84 | 27 | 69 | 35 | 43 | 14 | | |
| | Mean | 3.52 | 2.89 | 3.23 | 2.86 | 2.81 | 3.64 | 9.41 | <.001 |
| Self-assessment quizzes | N | 86 | 31 | 75 | 35 | 45 | 14 | | |
| | Mean | 2.53 | 2.61 | 2.56 | 2.77 | 2.58 | 2.57 | .45 | .81 |
| Tutor | N | 86 | 31 | 75 | 35 | 45 | 14 | | |
| | Mean | 3.69 | 2.65 | 3.32 | 2.77 | 2.82 | 3.79 | 15.26 | <.001 |

Table 2 - ANOVA Comparison of Learning Design elements' effect among examined groups

**Discussion**

In this research, we studied the impact of an intervention based on four combined pedagogical factors, aimed at supporting Physics' freshmen engaged in large size lectures.

Our research questions focused a number of critical issues in the context of the modernisation of higher education, namely the effectiveness of pedagogical approaches for large size lectures to the specific role played by MOOCs as specific pedagogical factor for freshmen engaged in large size lectures.

In spite of the claims on the problems generated by the numerosity of students in traditional courses (Yang, 2016), our integrated blended approach appeared to mitigate the negative effects large size lectures. This suggests that the lecture size, if properly handled through blended designs, should not influence the learning effectiveness. With all the precautions due to our non-experimental case study, we could assume that the combination of pedagogical factors (MOOC+active learning+self-monitoring and assessment+tutor guidance) was effective in terms of students' perceptions of effectiveness in their personal study. However, these results require further research, for each component could be contributing differently to the above mentioned perception. From one side, deeper subjective accounts, in order to understand the components of the students' perceptions should be considered. From the other side, objective instruments to measure and represent the impacts beyond the students' perception (i.e., knowledge, skills, study abilities, etc.), should be implemented. Moreover the tutor's role is still problematic and would require more attention. In fact, even if trained equally, each tutor influenced the students' opinion (relating the quality of learning) in significantly diversified ways.

Unfortunately, our research design prevented us to explore the objective effects of each pedagogical factor on learning effectiveness. Overall, this is an issue in the literature, since in ecological conditions the students cannot be overloaded with diversified tasks or assessment activities, nor can they be excluded from supposedly positive effects of a pedagogical approach. The survey with self-reported information on the pedagogical factors was an indirect way to explore their effectiveness. It was observed that MOOCs received the highest scores and there were no significant differences between the large and small size lectures. The overall active learning approach was perceived in a positive way with significant differences between groups. And the quizzes addressing self-evaluation were considered less relevant. In the literature, active and collaborative learning requires teachers' skills to design and orchestrate the settings as well as the students' participation (Kali, Levin-Peled, & Dori, 2009) We might suppose that the lecture size might also impact on the quality of active learning (Yang, 2016). If we pair the students' opinion on active learning with the students' opinion on the tutors, we find that the differences could be due either to the tutors' style or a group effect, since the highest scores coincide for the two dimensions. Therefore, from our results we could cautiously infer that the teacher's style needs to align with the students' expectations on what will happen in class, particularly in large size lectures. As for the quizzes for self-monitoring and assessment, more exploration on the motivations for the least attributed importance are necessary. The students could just be stressed or would need further support on the self-paced activities in order to better appreciate this component. This is in line with the idea that self-regulation in digital environments requires training

(Dabbagh & Kitsantas, 2003), and that the quizzes as element to build an independent approach to learning are but an element supporting independent learners.

The patterns of participation in MOOCs offered high variability and attrition in our case, aligning with the literature (Santos, Klerkx, Duval, Gago, & Rodríguez, 2014; Ulriksen et al., 2010). However, all the three elements of our approach were intensely used by the participants, and the fourth element (tutor's guidance) was appreciated. How the students profiled (if there were students more oriented to the face-to-face activities and preferred quizzes, or students who preferred the online elements), is a matter that requires further analysis. These elements should be further explored via qualitative approaches (interviews and focus groups) as well as via predictive statistical models based on learning analytics.

**Conclusions**

Exploring new approaches that encompass quality learning for large size classrooms with integrated MOOCs is raising attention and interest, as in the case of the "H-MOOCs" model introduced by (Pérez-Sanagustín et al., 2017). The presence of many variables and the complex architecture of an integrated pedagogical approach, yield fragmentary and data in our case. However, the case could be considered useful at the time of identifying the factors contributing to positive perceptions on the learning experience in large size lectures. Moreover, the role of MOOCs could be deemed relevant in these settings, even if its effects and students' profiles within the large size classrooms should be captured in their specific nuances, beyond the quantitative approach undertaken in our case. Our research has focused the problem of supporting the transitions from high school to higher education; of improving Physics teaching and learning as the base for STEM careers; of understanding which pedagogical factors can operate in large size lectures.

A particular interest goes to the type of combinations based on MOOCs more than as services, as resources to flip the class. This, in combination with the students' response systems, should be explored in both small and large size classrooms. In the literature, but also through our experience, the effectiveness of quizzes rely upon technology's novelty, as well as the power of immediate feedback to the student about his/her knowledge of the subject (Floratos et al., 2015). However, being prepared through self-paced MOOCs' activities, would improve the impact of proven effective elements such as the visualization, the explanations given by the tutor as formative assessment, the eventual peer-activities based on this feedback and the student individual differences in reacting to this feedback should be explored in detail.

With regard tutor's guidance as research problem, future research work could address the ways in which the teaching style, personal touch, content knowledge, communication, etc., specifically impact on students' experience and learning in combination with other pedagogical factors.

Overall, future research on large size lectures should consider the extent to which the number of students is sensitive to specific type of strategies, achieving learning effectiveness and quality. An important consideration regards the interdisciplinary collaboration required in studying large size lectures. Our approach required several professional profiles not only in order to design and implement the intervention but also, at the time, to evaluate it. In fact, beyond the initial team required to develop videos (content experts, teaching assistants/tutors, multimedia and instructional designers), the analysis of results encompassed the participation of the disciplinary and education coordinator, plus education researchers (2) and statistics experts (2). Along the case study, the above mentioned team had to cope with several problems that hindered the possibilities of exploring the relationships between the pedagogical approach and the learning process. However, the pleasure of collaborating was ensured by the common endeavour of improving learning in higher education, and the challenge posed by integrating MOOCs for large size lectures.

## Disclosure statement

No potential conflict of interest was reported by the authors

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