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► **To cite this version:**

Diaddin Hamdan, Frédéric Pamoukdjian, Jaqueline Lehmann-Che, Cédric de Bazelaire, Laetitia Vercellino, et al. A massive open online course to teach undergraduate medical students in oncology: keys of success. *Heliyon*, 2022, 8 (11), pp.e11306. 10.1016/j.heliyon.2022.e11306 . hal-03892064

HAL Id: hal-03892064

<https://hal.science/hal-03892064>

Submitted on 9 Dec 2022

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Research article

A massive open online course to teach undergraduate medical students in oncology: keys of success



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HIGHLIGHTS

- MOOC is appropriate for teaching undergraduate medical students.
- Socioeconomic factors and students' choice had a significant effect on final results.
- The digital format of MOOC is well suited to make all sorts of teaching evaluations.
- Students have better results with and are asking for blended teaching programs.

ARTICLE INFO

Keywords:

MOOC

Oncology

Medical undergraduates

Student perception

Success factors

ABSTRACT

Massive Open Online Courses (MOOCs) are gaining popularity in education while classroom lectures are being deserted, especially after COVID-19 pandemic. Their added value in teaching undergraduate medical students remains to be confirmed.

This study evaluated a MOOC devoted to undergraduate medical students in a blended oncology-teaching university program. It was the first to target undergraduate medical students in oncology at its beginning.

Students were asked to participate in a survey before and after MOOC to explore interactions between their characteristics and final grades, 65% of the participating students belonged to the rich class. 70% of the students completed the MOOC. Grades distributions were similar before and after MOOC implementation, so MOOC doesn't alter overall results. In addition, there was a positive effect of the MOOC on median grades on the immediate test. The univariate and multivariate analysis showed that socioeconomic status and student's willingness to participate interacted significantly with final results. Particularly, students' motivation and satisfaction were associated with better results; Almost 70% of students asked for blended learning.

E-learning is reliable to teach oncology to undergraduate medical students. The success is directly linked to students' willingness to participate, and can be improved using blended methods including tutorials.

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<https://doi.org/10.1016/j.heliyon.2022.e11306>

Received 16 June 2022; Received in revised form 30 August 2022; Accepted 24 October 2022

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1. Introduction

E-learning is increasingly used for medical education, the intention being to give more autonomy to medical students in a learner-centered process using online platforms and auto-evaluations [1]. The development of communication technologies, and more recently the COVID-19 pandemic, has facilitated the implementation of e-learning courses. Originally, a political and educational initiative for open-access educational resources was officially proposed with the Cape Town Open Education Declaration in 2007 [2,3]. This movement aimed to facilitate access to knowledge for life-long learning, and to favor higher education, providing high levels of qualification across all socio-economic categories [4]. Among the various E-learning types, Massive Open Online Courses (MOOCs) have several advantages: they are offered to thousands of learners with no prior qualifications, and are often available free online. They use specifically-designed multimedia content, self-assessed exercises, exams, and a discussion forum so this can be considered as a socio-constructivist approach to learning favoring personal autonomy development [5, 6]. In contrast, as disadvantages, they require a reliable internet connection which partly contributes to favor students with higher social and economic level [7]. In addition, this learning format limits interactions between participants [7], and the heterogeneity of MOOCs combined with the voluntary nature of participation make their evaluation very difficult [8].

MOOCs spread widely, with over 11,000 courses around the world, and more than 100 million learners registered from 2011 to 2018 [9, 10, 11]. In 2019, the total number of MOOCs reached 13500 [12]. MOOCs can be proposed to university students [13], but also to post-graduate students as part of continuing professional training [14]. In this case, participants are limited in numbers. MOOCs can also be addressed to the general public, to reach large numbers of learners [15, 16].

For medical education, MOOCs are gaining wide popularity [17, 18]. In the “health and medicine” domain, 225 MOOCs were listed in 2013, 113 of them being hosted by the search engine platform “Class Central” for example [15], and recently doubling the offer from 966 MOOCs in 2019 to 1888 in 2021 [19].

MOOCs devoted to medical education usually aim to increase public health literacy, promote continuing professional education, or improve undergraduate student learning [16, 20]. Whether MOOCs are keys of academic success regardless social and economic factors remains debated. Indeed, some authors claim that this pedagogic format does not fully alleviate socio-economic disparities [21], may be also because a lower socio-economic status is an unfavorable factor for higher education [22].

Undergraduate students are not the usual target audience of most MOOC providers [23], and the added value of this innovative pedagogy remains unclear for this population [18, 24, 25].

In this study, we evaluated the implementation of a MOOC dedicated to oncology for undergraduate third-year medical students in two universities in Paris. MOOC didn't exist in oncology. The idea was to introduce early the teaching of oncology through diagnosis, from the third year of medicine using this approach. We explored the impact of the students' characteristics in the context of this innovative pedagogic approach.

2. Materials and methods

2.1. Characteristics of the MOOC “Cancer Diagnostic Strategies”

The MOOC “Cancer Diagnostic Strategies” has previously been described [26]. It is proposed once a year with tailored contents for two types of learners, the general population and undergraduate third-year medical students in two Parisian universities. This course is compulsory at Université de Paris, and optional at Université Sorbonne Paris

Nord. It was implemented for the first time in 2016 as a part of a blended oncology teaching university program.

Medical oncologists, hematologists, radiologists, pathologists, biologists and psychologists from the two universities were involved in the elaboration of this MOOC, supported by the department of information and communication technologies for education of the Université de Paris. The MOOC consists of 27 units covered in 6 weekly modules, with an estimated weekly working time of 10 h, with video recordings, slide presentations using Publisher Express®, and portable document files. Over the 6-week period, medical students can interact with the pedagogic team via a discussion forum. The 6 modules are spread as followed: week 1 “From patient's symptoms to tumor biopsy”, week 2 “Macroscopic and microscopic analysis of tumor biopsy”, week 3 “Molecular analysis and identification of therapeutic targets”, week 4 “Work-up, multi-disciplinary committee and breaking the diagnosis”, week 5 “Pedagogic clinical cases of breast and colon cancers, lymphoma and a pediatric tumor”, week 6 “Pedagogic clinical cases of lung and prostate cancers, melanoma and leukemia”.

Formative assessments are proposed within and at the end of each module. Four weeks after the end of the MOOC, students had an examination in their respective universities for final validation of their undergraduate oncology program.

2.2. Pre- and post-MOOC surveys

For the first three years of this MOOC, students were asked to answer pre- and post-MOOC online surveys, in a two month period before and after the MOOC (Supplementary Tables 1 and 2). Email reminders were weekly sent. The surveys, written in French, had been accepted by the pedagogic and ethic committees in the participating universities, and comprised identity data, socio-economic data, and question to assess student perceptions and motivation towards this pedagogical approach. Informed consent was obtained for all participants prior to MOOC participation following the recommendations of the Declaration of Helsinki. The surveys had two objectives:

- To evaluate students' perceptions of the MOOC before and after its completion on 5-point Likert scales.
- To determine whether there was a relationship between students' characteristics (behavioral and socio-economic) and their perception of the MOOC and also their performances.

2.3. MOOC effect on students grades

An immediate 14-question test was used as a diagnostic and to evaluate the immediate pedagogic effect of the MOOC. The same test was carried out before and after the MOOC, with general knowledge questions (yes or no responses), and specialized ones (one correct answer) (Supplementary Table 3). Answers were coded in binary mode, one for correct, and zero for wrong. Pre- and post-MOOC scores were then compared for each question to assess percentages of correct answers after completing the MOOC.

Then, a final evaluation for the entire teaching program was carried out, and we used the final grades of students to analyze their performance and the effect of social and behavioral characteristics. We also analyzed the grades of students who followed the oncology undergraduate university program during the 2 years before MOOC implementation.

2.4. Coding of students' social and economic characteristics

Social characteristics included the students' age, sex, and marital status, coded in binary mode. The students' native language and the parents' birth country were coded according to geographical continental regions (Supplementary Table 4).

Students' socio-economic status were evaluated using parents' professions, classified according to the French National Institute of Statistic and Economic Studies (INSEE)¹ socio-professional categories (Supplementary Table 5) [27].

We also used indirect approaches [28, 29], by considering the type of accommodation, the individual familial situation (married/living with a partner or not, with or without child), and the use of a personal computer. Then we obtained gross domestic product (GDP)², poverty and median annual life levels for the administrative regions of residence [30, 31, 32]. We also used poverty and annual life levels in the cities of residence [33]. Finally, we used the parental INSEE socio-professional category to estimate parents' mean monthly salaries, poverty levels, median life level, and median annual available revenue [34, 35, 36, 37, 38, 39, 40]. Using all these data, we classified students into 5 categories of wealth (Supplementary Table 6 and Supplementary Figure 1) [41]. For net monthly income comparisons, we chose a couple with only one child as the reference family, since we did not have this information for all the students.

2.5. Literature search

For the literature review of MOOCs in teaching oncology to undergraduate medical students, we applied multiple ad-hoc algorithms composed of both thesaurus and free-text terms to search the MEDLINE[®] database up to 5 November 2021. The following algorithm was the most efficient: mooc [All Fields] AND undergraduate [All Fields].

2.6. Statistical analysis

Quantitative variables were described by their median and interquartile range (IQR)³, qualitative variables were described in numbers and proportions.

We assessed the final grades in a density plot, according to the year of student's enrollment before (2014–2015) and after (2016–2018) the MOOC implementation.

Participating students were compared according to their response to the survey for age, sex, university and grade of final evaluation using the Wilcoxon's test.

For the immediate evaluation, the medians of the students' results pre- and post-MOOC were compared using Wilcoxon's test for matched data and were graphically presented in a boxplot. Then, the percentage of students who answered correctly to each question in this evaluation was compared before and after the MOOC using McNemar's test with continued correction for matched data.

Final grade for students was classified according to the lowest quartile of 69%. The two groups (<69% and ≥69%) were compared according to initial student characteristics using the χ^2 test or Wilcoxon's test as appropriate. Univariate and multivariate logistic regressions were carried out to assess factors associated with the high grade score. The strength of association was expressed as adjusted Odds Ratio (aOR).

All tests were bilateral, and values were considered significant with a $P < 0.05$. The statistical analysis was performed on R software (version 4.1.0, R Foundation for Statistical Computing, Vienna, Austria, <http://www.R-project.org>).

3. Results

3.1. Students' general characteristics

A total of 1,774 undergraduate medical students were included in this study, over a period of 5 years from 2014 to 2018. The "Cancer

Table 1. General characteristics of the MOOC students responding the survey ($n = 420$).

Variables	%
Age (y)	20 [20–21] median [Q1–Q3]
Sex ratio F %	72
Marital status (ratio)	
Single vs Couple	96
Have no children	99.5
Most frequent native language	
French	77
Arabic	16
Other	8
Knowing MOOCs before (yes)	23.5
Ever participated to a MOOC before (yes)	5
Wanting to follow all the content of the MOOC (yes)	79.5
Enthusiastic to follow the MOOC (yes)	70

Diagnostic Strategies" MOOC was initiated in 2016 as a part of an oncology teaching university program, and data from the pre- and post-MOOC surveys and final evaluations were collected over the first three years (2016, 2017 and 2018). The total number of third-year medical students who participated to the MOOC was 1088 and was respectively 333, 383 and 372 for the three years.

An oncology program course was already delivered to third year medical students before the MOOC implementation, enabling to collect final grades of the students for the years 2014 and 2015, and corresponding to 334 and 352 students respectively.

When we only considered the 1,088 students who participated to the MOOC between 2016 and 2018, 420 of them (39 %) responded to the pre- and/or post-MOOC surveys (Table 1). Their median age was 20, and 77% were of French native language. The others had diverse cultural background, with 25 different native languages (data not shown). Almost all students were single (96 %), with no children (99 %), and 76% of them were still living with their parents.

For 23 % of them, a MOOC was a new teaching tool and 70 % were enthusiastic to participate.

When we compared the students who answered the surveys with the 730 who did not, they were younger women from the Université de Paris; with significantly better immediate evaluation grades (Table 2).

3.2. Students' economic characteristics

Among the 420 students who responded to the surveys, most of them belonged to the rich (65%) and middle classes (18.5%), on the basis of their parent's socio-professional category, and median annual available revenue of the family [35]. Fifteen percent of students belonged to the working class and 1.5 % to the poor class (Table 3).

Based on their socio-professional category, the median net monthly salary of the parents was 5 779 euros, with an interquartile range [3 940–7 880], corresponding to the rich class (Supplementary Figure 1).

The median poverty rate in the cities and administrative regions of residence was 16 %, compared to 14 % of the French territory as a whole [42].

3.3. Students' perceptions

The MOOC completion rate was obtained from the post-MOOC survey. Seventy percent of the students completed the MOOC (Supplementary Figure 2A), which is a high percentage compared much lower completion rates reported in the literature [43]. Almost 90 % of the students who responded were satisfied with the MOOC (Supplementary Figure 2B), and the majority of participating students (60 %) thought that this MOOC was more interesting than conventional lecture classes. Interestingly, 69% expressed the need for tutorials too (Supplementary

¹ INSEE: French National Institute of Statistic and Economic Studies.

² GDP: Gross Domestic Product.

³ IQR: Interquartile range.

Table 7), highlighting the benefit of blended/hybrid models combining face-to-face and e-learning for student's satisfaction [44].

Eighty percent of the students were satisfied with the resources used in the MOOC (slides, videos, explanations, and evaluations) and with its pedagogic quality. However and despite an estimated weekly working time of 10 h, 50 % of the students thought that it was much higher than they expected. Indeed, in the literature, the median working time devoted to a MOOC is 4.2 h per week [45].

3.4. Immediate and late effects of the MOOC on academic success

First, we calculated final grades for students enrolled between 2014 and 2015 (before the MOOC implementation) and students enrolled between 2016 and 2018 (after the MOOC implementation). The distribution of median grades was similar between these two groups suggesting that the MOOC did not alter students' performance (Figure 1).

Then, using a 14-question MOOC evaluation, we showed an immediate positive effect of our MOOC on the median student grades, with a two-point improvement for the post-MOOC compared to the pre-MOOC assessment for the 77 students who completed this assessment (Figure 2). For each question, we compared the number of students who gave a correct answer before and after completing the MOOC; specialized cancer questions were discriminant questions with a $P < 0.05$ (Supplementary Figure 3).

3.5. Factors associated with success in the MOOC

To explore the effects of social and economic factors on final grades of students enrolled in the MOOC, we did a univariate and multivariate analysis. When we considered the 420 students who participated to the MOOC and answered the pre-MOOC survey, the final grade data was available for 404 of them. We separated the students into quartiles according to their final grades and chose the first quartile over 69% to distinguish the best students. We showed that 11% of students with a final grade less than 69% did not have a personal computer compared to 4% of students with a final grade over 69% (ns). Using this cut-off of 69%, univariate analysis identified younger age, female sex, Université de Paris affiliation, median administered area GDP of at least 96 400 euros, living communal poverty rate less than 16.2 %, willing and enthusiasm to follow the MOOC as factors associated with academic success. In multivariate analysis, female sex, Université de Paris affiliation, median administered area GDP of at least 96 400 euros and willing to follow the MOOC remained significantly associated with academic success (Table 4).

4. Discussion

MOOCs have gained wide popularity as a new pedagogic tool, providing online access to a large panel of resources for university

Table 2. General characteristics of MOOC-participating students according to their participation status to the survey (n = 1,088).

Variables	Participate to the survey (n = 420)	Did not participate to the survey (n = 668)	P*
Age (y), median [Q1-Q3]	20.0 [19.0–20.0]	20.0 [19.0–21.0]	0.005
Sex ratio (F)	72%	60%	0.0005
Université de Paris vs Université Sorbonne Paris Nord (ratio)	95%	92%	<0.0001
Grade of final evaluation (mean) [Q1-Q3]	75% [66–80]	70% [65–75]	<0.0001

* P value for Wilcoxon's test.

Table 3. Economic characteristics of MOOC-participating students (n = 420).

Variables	%
Personal computer	94
Professional activity during MOOC	21
Housing	
Parents	76
Alone in an apartment	16
Others	8
Median salary per month \geq 5779 €	58
Median administered area GDP 2015 \geq 96400 €	67
Median administered area poverty rate \geq 16.2 %	76
Median communal poverty rate \geq 16.2%	23
Socio-professional class	
- Rich	65
- Middle	18.5
- Working	15
- Poor	1.5

GDP: growth domestic product of 2015.

students [17, 46, 47]. MOOCs seem to be well-suited to our connected society, giving students more flexibility and autonomy in the management of their time [5]. 70% of our students completed the MOOC which is high and possibly biased by the fact that the course was mandatory for Université de Paris. Despite this, this high completion rate is an important point at a time when classroom lectures seem to be increasingly deserted [48], and even more since the COVID-19 pandemic when MOOC helped to remove physical barriers in teaching [49, 50]. However, students need to keep up social connections with colleagues, as expressed by 69% of students in our study who claimed the need for tutorial too despite being satisfied by the MOOC itself. These are important for learning, as proposed by the socio-constructivist model, which is popular in medical studies [51]. This might explain a better success for students of Université de Paris for whom the MOOC was not the only pedagogic content, since it was combined with tutorials, wished by all students. This might also explain the better results of women as they tend to use more efficiently social connections, and in addition, they show more commitment and dedicated time to follow instructions and do exercises while men are more often over-confident [52, 53].

To our knowledge, our MOOC “Cancer Diagnostic Strategies” was the first MOOC teaching oncology to undergraduate medical students in the time when it was implemented. In September 2019, there were 2 MOOCs dedicated to cancer on the French-language “France Université Numérique” platform, and 24 on the English-language Class Central MOOC search engine. All of them were devoted to the general public, and not to undergraduate medical students [19, 54]. In addition, using the algorithm: mooc [All Fields] AND undergraduate [All Fields] on MEDLINE® database, we retrieved 15 articles, and only 3 papers on MOOCs teaching undergraduate students [13, 55, 56, 57]. One of them, teaching anatomy, evaluated student satisfaction and concluded that students did not desire the complete replacement of existing teaching by the MOOC [13]. Our study also underlines this major consideration. This highlights the benefit of using blended models combining face-to-face tutorials and e-learning as keys of success for medical education and student satisfaction [58, 59].

Besides, we showed that students' satisfaction and willingness to participate are factors associated with academic success, in accordance with another MOOC dedicated to undergraduate medical students also evaluated for their performance before and after completion of the MOOC. Using another approach with structural equations, they underlined, as in our study, that a higher motivation leads to better academic results and then to an improvement in empathy and communication skills [57]. Recently, we carried out a literature review using the algorithm:

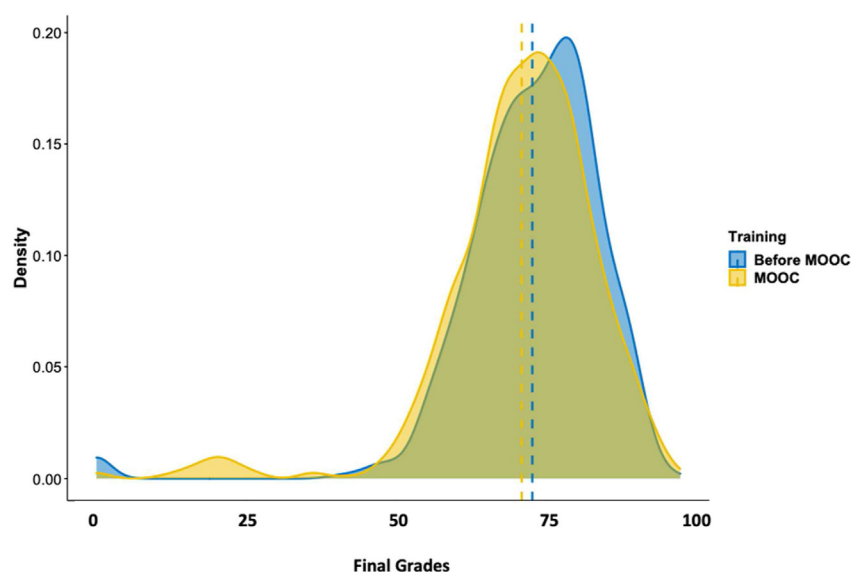


Figure 1. Density plot of the final grades according to the years of students enrollment in our undergraduate university oncology program before (2014, 2015) versus after MOOC implementation (2016–2018) (n = 1,774 students). Median grades of the years before MOOC = 75 [65–80] and median grades of the years after the implementation of the MOOC = 70 [65–80]. In the sub-group of the final grades between 40 and 60, the proportion of students were significantly different according to the periods: 9% (59/686) and 11% (122/1,088), $P = 0.02$, before and after MOOC implantation respectively.

moooc [All Fields] AND student [All Fields] AND motivation on MEDLINE® database, we found 16 articles highlighting students’ motivation role in academic success [60, 61, 62, 63, 64, 65, 66]. A recent work by Badali *et al* confirmed our conclusion also [67].

The MOOC did not alter the academic success of our students, compared to anterior teaching method [58]. Apart from the classical final evaluation, we included an immediate evaluation which was an originality of our study. Most publications on MOOCs have addressed the question of MOOC evaluation on the basis of the course completion rate, with no immediate summative assessment [43, 47, 68, 69]. As showed by the results of specialized questions, students immediately improved their grades for current knowledge items while knowledge that tend to be more specialized items are more difficult to improve. A limitation is that the questions addressed only cognitive competence (or declarative knowledge). We intend to add clinical reasoning evaluation in upcoming

sessions, as reflection is considered an important part of efficient learning [70, 71].

Another strength of our study was to assess the keys of academic success regarding to social and economic factors. A main result is that this pedagogic format does not fully alleviate socio-economic disparities [21, 72, 73]. That is the reason why sociologists have claimed that MOOCs are not a democratic teaching format [74]. This is partly true as lower socio-economic status is an unfavorable factor for higher education [22]. However, as other studies [75], we also showed that students belonging to lower socio-economic categories can improve their academic level, even if their success rate is lower than for students with higher socio-economic status. This implies their willingness to really participate in this teaching experience [68, 76].

The long-term pedagogic effect of MOOCs on knowledge acquisition also needs to be evaluated [77]. Anyway, the evaluation process we built

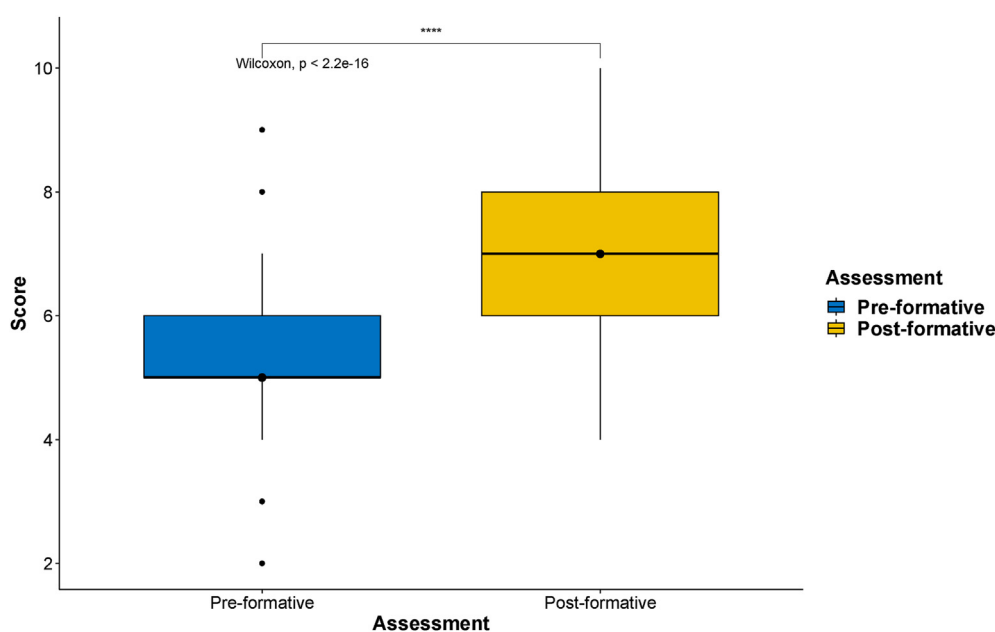


Figure 2. Boxplot of the MOOC immediate evaluation grade (Max = 10) according to the formative status (n = 77 students) for the years 2016–2018. Median grade of the pre-MOOC assessment = 5.0 [5.0–6.0] compared to Median grade of the post-MOOC assessment = 7.0 [6.0–8.0].

Table 4. Uni- and multivariate factors associated with high final grade of our undergraduate university oncology program for the students participating in the MOOC.

Variables	Score <69% (n = 133) %	Score ≥69% (n = 273) %	P*	aOR	[95%CI]	P**
Age (y), median [Q1-Q3]	21 [20–21]	20 [20–21]	0.01	-	-	
Sex Female	65	74	0.06	0.55	[0.34–0.96]	0.02
Université de Paris	93	98	0.02	4.02	[1.17–13.9]	0.02
Personal computer	89	96	0.42			
Marital status (single)	97	96	0.60			
Housing			0.90			
Parents	77	75				
Alone in an apartment	16	17				
Others	7	8				
Native language			0.48			
French	74	79				
Arabic	16	15				
Others	10	6				
Have no children	100	99	0.32			
Professional activity during MOOC	22	21	0.89			
Economic data (median):						
Salary per month ≥5779 €	50	55	0.44			
Administered area GDP ≥96400 €	59	71	0.04	1.69	[1.00–2.48]	0.04
Administered area poverty rate ≥16.2 %	73	76.5	0.58			
Communal poverty rate ≥16.2%	30	18	0.005	-	-	-
Socio-professional class			0.14	-	-	-
-Rich	60	67				
-Middle	22.5	17				
-Working	14.5	15				
-Poor	3	1				
Knowing MOOCs before	24	46	0.69			
Ever participated to a MOOC before	7	4	0.16	-	-	
Wanting to follow all the content of the MOOC	70	84	0.001	3.16	[1.79–5.56]	<0.0001
Enthusiastic to follow the MOOC	62	71	0.04	-	-	

*Chi2 test or Wilcoxon's test as appropriate; **P value for multivariate logistic regression; F: femme, GDP: growth domestic product of 2015. **Bold:** significant P value at the threshold of 5%.

in this study, evaluating both students and the MOOC by itself, is implementing processes at the cornerstone of future accreditation process for health medical schools.

5. Conclusion

E-learning provides reliable pedagogic tool to teach undergraduate medical students in the field of oncology, and can be complementary to conventional classrooms. The success is directly linked to students' willingness to participate, and can be improved using blended methods including tutorials. The positive results of our MOOC have led to an ongoing plan to offer it nationally to other schools of medicine.

Declarations

Author contribution statement

Diaddin HAMDAN; Géraldine Falgarone; Guilhem Bousquet: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Frédéric Pamoukdjian: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Jaqueline Lehmann-Che; Cédérique de bazelaire; Laetitia Vercellino; Julien Calvani: Performed the experiments; Wrote the paper.

Maxime Battistella: Performed the experiments; Wrote the paper.

Philippe Bertheau: Conceived and designed the experiments; Performed the experiments; Wrote the paper.

Funding statement

This work was supported by the “Investissements d'Avenir” measures, and Sorbonne Paris Cité University.

Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

Supplementary content related to this article has been published online at <https://doi.org/10.1016/j.heliyon.2022.e11306>.

Acknowledgements

We would like to thank Mrs. A. Verdier for revising the English language.

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