ACTIVE LEARNING METHODOLOGIES, STUDENT MOTIVATION, AND DROPOUT: A PILOT STUDY IN SCIENCE AND ENGINEERING DEGREES

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Abstract

This paper presents a pilot study on the impact of active learning methodologies on student motivation and course dropout in Science and Engineering degrees.

This study is part of a two-phase project. The first phase designs an initial data collection instrument and applies it to selected courses in two schools of Science and Engineering from the Universidad Rey Juan Carlos (Spain). This pilot study corresponds to this phase, aiming to validate the instrument through statistical and psychometric analysis. The sample consisted of 216 participants from five different university degrees, three from the Engineering branch related to the Computer Science discipline and two from the Science branch related to the Chemistry discipline. All courses belonged to the first year and were chosen because they had a significant risk of dropout.

The instrument is a questionnaire that addresses different aspects within the context of the course where it is facilitated. Thus, participants answered the questionnaire in person. The instrument asked about the probability of absenteeism and dropout of both, course, and degree; the expectation regarding the grade, and other data that characterizes the student. In addition, it asked about motivation using a Situational Motivation Scale validated in other contexts. Regarding active learning methodologies, it asked if any active methodologies have been used in the course, such as collaborative or cooperative learning, flipped classroom, project-based learning, serious games, video-based learning, escape room, and other approaches that encourage student involvement such as gamification.

After analyzing the results of this first questionnaire, we can draw several conclusions. First, we can confirm that the motivation construct used in the instrument is valid. The correlations between the different aspects measured have been studied, and no correlation has been detected with aspects such as the family's economic effort for studies or the type of internet access used by the student. Medium-level correlations have been detected between some form of motivation and either student habits or active learning methodologies.

Since the correlations identified in this study are not definite, the main result is the validation of the questionnaire that will be used in the following phase of the project.

Keywords: Active learning, motivation, dropout, science, engineering, higher education, pilot study, validation, instrument.

1 INTRODUCTION

One of the challenges in university education is student attrition. Sometimes, this attrition occurs at the undergraduate level, while other times it pertains to specific course offerings or even elective subjects. Undoubtedly, the first type of dropout is more severe and tends to receive greater attention, but the latter often goes unnoticed, sometimes not even recognized as a problem.

An illustrative example is the introductory programming course offered in the first year of computer science studies. It stands out as one of the few courses that explicitly address this issue. While recent studies have explored other topics, such as data structures [1], the overall investigation into this problem remains limited.

There is a consensus regarding the significant difficulty of the introductory programming course, as evidenced by various multinational studies (e.g., [2]). This difficulty often translates into a high dropout rate for the course. For instance, the seminal work by Bennedsen and Caspersen [3] reported findings from professors at 63 universities across the United States, Europe, and Australia. The results varied

widely, but on average, approximately one-third of students either failed or abandoned the course. Subsequent studies have corroborated similar outcomes [4].

Other studies have delved into the reasons behind these course dropouts. Kinnunen and Malmi [5] identified key factors such as time constraints and lack of motivation. Additionally, these reasons were influenced by the perception of the course difficulty and challenges related to time management and study planning.

While subsequent authors have corroborated these reasons, there seems to be a crucial moment when students make a thoughtful decision to drop out [6]. Although both continuing and dropout students experience this moment, it appears that those who abandon prioritize other challenges or simply perceive themselves as incapable of progressing in the course. However, students who persist acknowledge the necessity of trial-and-error processes and the time they require. This point can be exacerbated by a lack of alignment between assessment activities and the expectations set. For instance, students often enroll with the expectation that assignments can be solved based on memory or comprehension, while instructors anticipate their ability to create programs from specifications. It is also common for learning objectives to be misaligned with assessment activities. In the case of female students' dropout, comparison with peers, social factors, perceived difficulty of the subject, and achievement-related self-perception play prominent roles [7].

An objective reason that has been highlighted is that professors' expectations regarding what students should learn within a single course are often too high. According to Luxton-Reilly [8], the issue does not lie with the students or the instructional approach, but rather with the assessment process. There seems to be a lack of awareness that students need more time than a single semester to meet these great expectations. Furthermore, initial assignments should emphasize memorization and comprehension rather than immediate application. For instance, incorporating reading comprehension questions or practical exercises in the computer lab would be more effective. This excessive demand aligns with the analysis conducted by Dobele et al. [9], who compared programming courses to networking subjects. Interestingly, contrary to expectations, the cognitive level required in lower-level programming courses was significantly higher than that in other upper-level subjects.

From a student's perspective, it is worthwhile to explore their experience [10]. Often, emotional aspects such as anxiety and frustration in the face of difficulty come into play. Various measures have been implemented, including peer learning, mentoring, and support for underrepresented groups (such as women in computer science).

An essential factor lies in how to motivate students effectively. Previous research suggests that, rather than relying solely on external rewards to drive student learning, it is crucial to focus on fostering intrinsic motivation [11]. In pursuit of this goal, active teaching and learning methodologies play a pivotal role within the educational context [12]. Consequently, investigating active educational methodologies to enhance intrinsic motivation remains a relevant factor [13]. Notably, positive impacts on motivation and academic outcomes have been observed [14,15].

Several factors can be influenced by motivation, and one of them is school dropout [16]. It is evident that higher intrinsic motivation and increased personal effort reduce the risk of abandonment and attrition in academic studies [17]. The high levels of university dropout rates, along with the significant economic and personal costs it incurs, have prompted numerous research studies to explore strategies for mitigating this issue [18]. However, these prevention strategies depend on multiple factors [19], where active learning strategies can positively impact student motivation [20].

The proposed project aims to examine various factors influencing course abandonment, with special attention to the impact of active methodological activities on student motivation to persist in their learning journey. While some studies have detected improvements in student attitudes after participating in active methodologies e.g., [21,22], there are cases where these approaches do not significantly affect attitude [23] or even course dropout rates [24]. This analysis will allow us to work toward reducing student attrition and enhancing motivation by refining and aligning active teaching methods in the classroom, striking a balance between improved learning outcomes and potential negative effects on students.

The negative effects observed in students manifest at the cognitive level, often stemming from unmet knowledge expectations. Additionally, their behavior plays a crucial role, where their level of interest and commitment to implemented active methodologies can significantly affect their final academic performance in the course. Furthermore, their motivation and satisfaction with these methodologies are key factors. The demanding nature of active participation may lead to student discouragement and psychological fatigue, potentially increasing their desire to abandon the subject. Therefore, this study will explore the influence of these affective and cognitive domains on student academic achievement and their propensity to drop a course.

2 METHODOLOGY

The methodology employed in this article centers on achieving starting objectives through a series of work phases, within an educational framework involving five subjects from different degree programs. These subjects correspond to five knowledge areas included in two schools belonging to Rey Juan Carlos University of Madrid (URJC). Initially, the work protocol for the study is developed with the design of the instrument used, subsequently distributed among students to collect answers for data processing and results analysis.

The present study is part of an educational project awarded to the research team of this article, under the Projects Call of the URJC Student Observatory for the 2023 academic year. This call aims to fund projects focused on analyzing the needs and sensitivities of students. Specifically, the mentioned project is entitled: "Impact of active teaching methodologies on student motivation and subject dropout in the fields of sciences and engineering". Furthermore, this project is certified by the Research Ethics Committee of the URJC with registration number 1909202332423, confirming agreement to the ethical requirements outlined in the study protocol regarding its objectives.

2.1 Hypothesis and Objectives

The case study presented in this contribution is guided by the following hypothesis: Active methodologies, in conjunction with personal, social, and academic factors, positively impact student motivation, resulting in a decrease in course dropout rates. The initial hypothesis of this article draws support from both the findings of our research team and existing literature in the field [25–28].

To address this hypothesis, the study aims to achieve the following objectives:

1 Assess the impact of active methodologies on student motivation within the academic setting.

2 Identify the significant personal, social, and academic factors influencing student motivation.

3 Develop and validate an assessment tool capable of accurately measuring the impact of active methodologies on student motivation.

4 Explore the effectiveness of specific active methodologies in enhancing student motivation and reducing dropout rates.

Regarding the first objective, the study aims to evaluate how active learning influences student motivation within the educational environment. By examining various active learning approaches such as collaborative or cooperative learning, flipped classroom models, and project-based learning, among others, the research seeks to understand how these methods impact student engagement and persistence. Understanding this relationship is essential for educators and policymakers seeking to improve student retention rates and academic outcomes.

Moving to the second objective, the focus lies on identifying significant personal, social, and academic factors influencing student motivation, particularly in relation to active learning approaches. This includes investigating how factors such as self-efficacy, peer interactions, and how students perceive the relevance of course content interact with active methodologies to impact student motivation. By elucidating these connections, the study aims to provide valuable insights into tailoring educational interventions to enhance student engagement and retention.

Regarding the third objective, the study aims to develop and validate an assessment tool capable of accurately measuring the impact of active methodologies on student motivation. This involves refining the assessment instrument through rigorous statistical analyses, such as Cronbach's Alpha and principal component analysis, to ensure its reliability and validity. By creating a robust measurement tool, the study seeks to provide educators with the means to assess the effectiveness of active learning strategies in promoting student motivation and academic success.

Lastly, the fourth objective involves exploring the effectiveness of specific active methodologies in enhancing student motivation and reducing dropout rates. By examining the relationship between these methodologies and student motivation, the study aims to provide insights into effective pedagogical approaches for promoting student engagement and persistence. Through this exploration, the study aims to contribute to the development of evidence-based practices that support student success in higher education.

2.2 Educational context

The present study is included in an educational context involving subjects from two different schools within the URJC. Table 1 indicates the subjects involved in the study, as well as the degrees, courses and knowledge areas of the corresponding schools.

Table 1. Subjects, courses, knowledge areas and schools of the study.

Superior Technical School of Computer Science Engineering				***Higher School of Experimental Sciences and Technology***			
Subject	Degree	Course and Semester	Knowledge area	Subject	Degree	Course and Semester	Knowledge area
Visual Programming	Video Game Desing and Development	1st, 1st	Computer Science Languages and Systems	Chemistry	Biology	1st, 1st	Analytic Chemistry Physical Chemistry Inorganic Chemistry Organic Chemistry
Introduction to Programming	Informatics Engineering	1st, 1st		Chemistry	Environmental Science	1st, 1st-2nd	
Object-Oriented Programming	Computer Engineering	2nd, 1st					

As shown in Table 1, the selected subjects belong to the initial courses of each degree program, where high student dropout rates have been identified and motivation issues are expected to be more significant.

2.3 Protocol of the study

The following protocol provides a detailed guide for conducting the study about the impact of active learning methodologies on student motivation and dropout. By carefully following these steps, the validity and reliability of the results obtained can be ensured, contributing to the advancement of knowledge in this research field.

2.3.1 Instrument Design

The instrument objective is to develop an assessment tool through statistical and psychometric analysis, ensuring accurate and reliable measurement of the impact of active learning methodologies on student motivation and dropout.

Key elements related to student motivation and dropout within the context of active learning methodologies will be identified in the instrument developed. Clear and concise items addressing these elements will be designed, utilizing validated measurement scales whenever possible.

Content validity will be evaluated through expert review in the field to ensure the instrument's relevance and appropriateness. Additionally, reliability analysis, including Cronbach's alpha coefficient, will be conducted to assess the internal consistency of the instrument. Statistical techniques such as factor analysis will also be applied to examine the construct validity of the instrument

2.3.2 Distribution

The participants comprised a representative sample of 216 students from five different university degrees, including three from the Engineering branch related to the Computer Science discipline and two from the Science branch related to the Chemistry discipline. They were selected based on a significant risk of dropout, identified through careful assessment.

For the distribution process, permissions were obtained from the Deputy Vice-Chancellor of students and the corresponding School Directors. Coordination efforts were made with each grade's responsible individuals and course delegates to schedule the distribution of the instrument. Clear instructions on how to complete the instrument and deadlines for its return were provided online via two Microsoft Sway links, one for each School, facilitating direct access to the survey.

Ethical considerations were paramount, with informed consent sought from all participants before distributing the instrument. Confidentiality of collected data and the anonymity of participants were ensured throughout the study to uphold ethical standards and protect participant privacy

2.3.3 Students' Response (Consent and Questionnaire)

The consent process will involve providing participants with a clear and understandable explanation of the study's purpose, procedures, and potential risks and benefits. Written informed consent will be obtained from each participant before their voluntary participation, ensuring that autonomy is respected.

Regarding the questionnaire, participants will receive assurance that they understand the questions and can respond accurately. Additionally, assistance will be available to those who may require help completing the questionnaire, ensuring that all participants can fully engage with the study.

2.3.4 Data Collection and Protection, and Analysis of Results

The data collection period will be carefully planned to align with academic schedules and the school calendar, ensuring that instruments are distributed and collected within an appropriate timeframe.

During the collection process, completed instruments will be promptly collected and securely stored. Any encountered issues or anomalies will be documented for later analysis and resolution.

Data protection measures will be strictly followed, adhering to ethical guidelines established by the Ethics Committee to safeguard participant confidentiality.

For statistical analysis, appropriate techniques such as analysis of variance (ANOVA), correlation tests, and regression analysis will be employed. The results of the analysis will be interpreted in relation to the study's objectives and hypotheses.

2.4 Description of the instrument

A questionnaire of fifty-five questions has been designed. The questionnaire measures the value of 43 variables, and is divided into six blocks. In the first block of questions (1-4), the student's feelings about the subject are measured: their probability (measured from 0 to 100) of not attending class, dropping the subject and dropping the degree they are studying, and the grade (from 0 to 10) expected in the subject.

The second block consists of personal questions (5-17), such as age, gender, years enrolled in the subject and the degree, route of access to the degree, whether it was their first choice, time and means of transportation to get to the university, and whether they received financial aid to study.

In the next block (questions 18-33), the student's motivation regarding the subject is measured using a 7-point Likert scale, ranging from "does not correspond at all" to "corresponds completely". The question of why you are taking this subject now is answered.

Questions 34-42 refer to the teaching methodologies used in the subject. With yes or no questions, it is found out whether collaborative/cooperative learning, flipped classroom, gamification, game-based learning, or video-based learning have been used.

In the block that encompasses questions 43-52, the same 7-point Likert scale is used, ranging from "does not correspond at all" to "corresponds completely". This block measures the suitability of the teaching activities of the subject and the student's study habits. There are also three questions (53-55) that refer to study techniques, place, and hours of study.

3 RESULTS

The questionnaire was completed by 225 students and the average completion time was 13 minutes. The results of the factorial analysis have been satisfactory and the validity of the motivational scale has been confirmed (Cronbach's alpha > 0.7). In addition, a correlational analysis was performed showing many significant correlations ($p<0.05$), but only those with Pearson's coefficient r greater than 0.4 are reported in this study.

Thus, 22 correlations were detected among 12 variables, out of the 43 ones measured with the questionnaire. These correlations are presented in two groups, those related to motivation variables (see Table 2) and those detected among different study habits and preferences for pedagogical techniques (see Table 3).

Table 2. Significant correlations involving motivation variables.

	Intrinsic motivation	*Identified regulation*	*Demotivation*
Review of materials before class	-	r = 0.414	-
Use of practices and exercises during class	r = 0.512	r = 0.571	r = -0.517
Preference for team discussions	-	r = 0.421	-
Preference for Problem Based Learning	r = 0.430	r = 0.408	-

Table 3. Significant correlations involving variables related study habits and preferences for pedagogical techniques.

	Preference for Problem Based Learning	*Daily study pace*	*(1)*	*(2)*	*(3)*	*(4)*
Preference for team discussions (1)	r = 0.430	-	N/A	-	-	-
Review of materials before class (2)	r = 0.422	r = 0.417	r = 0.417	N/A	-	-
Use of practices and exercises in class (3)	r = 0.597	r = 0.421	r = 0.535	r = 0.550	N/A	-
Preference for Video Based Learning	r = 0.641	-	-	r = 0.446	r = 0.438	-
Preference for Educative Scape-room	r = 0.431	-	r = 0.571	-	-	r = 0.731
Preference for Serious Games (4)	r = 0.536	-	-	-	-	N/A
Preference for Gamification	-	-	-	-	-	r = 0.498

4 CONCLUSIONS

After analysing the data collected, it can be concluded that no correlation has been found regarding absenteeism or course/degree dropout. Questions about family's economic effort for studies or the type of internet access used by the student show no correlation with any other variables, therefore they will be removed form the future questionnaire.

However, a medium level correlation has been found relating intrinsic motivation with both, the use of practices and exercises during class, and the preference for Problem Based Learning. Identified regulation is correlated with previous aspects together with the student habit of reviewing materials before class and the preference for team discussions. In addition, some methodologies seem to be highly correlated, as the pairs: Problem Based Learning with Video Based Learning, and Serous Games with Educative Scape-room.

Correlations detected are not definitive, but they provide future lines of work where the instrument will be applied to a larger population. However, the main result of this pilot study is a validated instrument that aims to facilitate the detection of aspects that may influence student motivation and dropout of courses and degrees, including the use of active learning methodologies.

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REFERENCES

[1] Hooshangi S, Ellis M, Edwards SH. Factors influencing student performance and persistence in cs2. En: Proceedings of the 53rd ACM Technical Symposium on Computer Science Education-Volume 1. 2022. p. 286-92.

[2] Lister R, Adams ES, Fitzgerald S, Fone W, Hamer J, Lindholm M, et al. A multi-national study of reading and tracing skills in novice programmers. ACM SIGCSE Bulletin. 2004;36(4):119-50.

[3] Bennedsen J, Caspersen ME. Failure rates in introductory programming. AcM SIGcSE Bulletin. 2007;39(2):32-6.

[4] Watson C, Li FW. Failure rates in introductory programming revisited. En: Proceedings of the 2014 conference on Innovation & technology in computer science education. 2014. p. 39-44.

[5] Kinnunen P, Malmi L. Why students drop out CS1 course? En: Proceedings of the Second International Workshop on Computing Education Research [Internet]. New York, NY, USA: Association for Computing Machinery; 2006. p. 97-108. (ICER '06). Disponible en: https://doi.org/10.1145/1151588.1151604

[6] Petersen A, Craig M, Campbell J, Tafliovich A. Revisiting why students drop CS1. En: Proceedings of the 16th Koli Calling International Conference on Computing Education Research. 2016. p. 71-80.

[7] Barr M, Kallia M. Why students drop computing science: using models of motivation to understand student attrition and retention. En: Proceedings of the 22nd Koli Calling International Conference on Computing Education Research. 2022. p. 1-6.

[8] Luxton-Reilly A. Learning to program is easy. En: Proceedings of the 2016 ACM Conference on Innovation and Technology in Computer Science Education. 2016. p. 284-9.

[9] Oliver D, Dobele T, Greber M, Roberts T. Comparing course assessments: When lower is higher and higher, lower. Computer Science Education. 2004;14(4):321-41.

[10] Luxton-Reilly A, Simon, Albluwi I, Becker BA, Giannakos M, Kumar AN, et al. Introductory programming: a systematic literature review. En: Proceedings companion of the 23rd annual ACM conference on innovation and technology in computer science education. 2018. p. 55-106.

[11] Deci EL, Koestner R, Ryan RM. Extrinsic rewards and intrinsic motivation in education: Reconsidered once again. Review of educational research. 2001;71(1):1-27.

[12] Schunk DH, Pintrich PR, Meece JL. Motivation in education: Theory, research, and applications [Internet]. 3rd ed. Upper Saddle River, N.J. : Pearson/Merrill Prentice Hall; 2008. 433 p. Disponible en: https://searchworks.stanford.edu/view/6774934

[13] Serrano-Cámara LM, Paredes-Velasco M, Alcover CM, Velazquez-Iturbide JÁ. An evaluation of students' motivation in computer-supported collaborative learning of programming concepts. Computers in human behavior. 2014;31:499-508.

[14] Paredes-Velasco M, Velázquez-Iturbide JÁ, Gómez-Ríos M. Augmented reality with algorithm animation and their effect on students' emotions. Multimedia Tools and Applications. 2023;82(8):11819-45.

[15] Urquiza-Fuentes J, Paredes-Velasco M. Investigating the effect of realistic projects on students' motivation, the case of Human-Computer interaction course. Computers in Human Behavior. 2017;72:692-700.

[16] Kehm BM, Larsen MR, Sommersel HB. Student dropout from universities in Europe: A review of empirical literature. Hungarian Educational Research Journal. 2019;9(2):147-64.

[17] Larsen MR, Sommersel HB, Larsen MS. Evidence on dropout phenomena at universities [Internet]. Danish Clearinghouse for educational research; 2013. Disponible en: https://dpu.au.dk/fileadmin/edu/Udgivelser/Clearinghouse/Review/Evidence_on_dropout_from_universities_brief_version.pdf

[18] Liu WC, Wang JCK, Ryan RM. Building autonomous learners: Perspectives from research and practice using self-determination theory. 2016;

[19] Ricard NC, Pelletier LG. Dropping out of high school: The role of parent and teacher self-determination support, reciprocal friendships and academic motivation. Contemporary Educational Psychology. 2016;44:32-40.

[20] Entezari M, Javdan M. Active Learning and Flipped Classroom, Hand in Hand Approach to Improve Students Learning in Human Anatomy and Physiology. International Journal of Higher Education. 2016;5(4):222-31.

[21] Demirci C. The Effect of Active Learning Approach on Attitudes of 7th Grade Students. International Journal of instruction. 2017;10(4):129-44.

[22] Özer S. The Effect of Active Learning on Achievement and Attitude in Vocational English Course. ie: inquiry in education. 2020;12(2):13.

[23] Nurbavliyev O, Kaymak S, Sydykov B. The effect of active learning method on students' academic success, motivation and attitude towards mathematics. Journal of Language and Linguistic Studies. 2022;18(2).

[24] Kvam PH. The effect of active learning methods on student retention in engineering statistics. The American Statistician. 2000;54(2):136-40.

[25] Frémont H, Arnal F. To avoid dropout: let student teach! En: 2021 30th Annual Conference of the European Association for Education in Electrical and Information Engineering (EAEEIE). IEEE; 2021. p. 1-5.

[26] Vergara D, Paredes-Velasco M, Chivite C, Fernández-Arias P. The challenge of increasing the effectiveness of learning by using active methodologies. Sustainability. 2020;12(20):8702.

[27] Portal Martínez E, Arias Fernández E, Lirio Castro J, Gómez Ramos JL. Fracaso y abandono universitario: percepción de los (as) estudiantes de Educación social de la Universidad de Castilla La Mancha. Revista mexicana de investigación educativa. 2022;27(92):289-316.

[28] Ugwulor-Onyinyechi CC, Tunca EA, Anselm AU, Anazor AE, Odoh GC, Gever VC, et al. Impact of visual multimedia as a counselling strategy for reducing school dropout propensity among school children who are survivors of abductions in Northern Nigeria. Journal of Asian and African Studies. 2022;57(7):1401-13.