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Rediseño iterativo de un curso autogestivo para la enseñanza de probabilidad y estadística en modalidad virtual a nivel posgrado

Iterative redesign of a self-managed course for teaching probability and statistics at graduate level in distance education

Redesenho iterativo de um curso autogerido para ensino de probabilidade e estatística online em nível de pós-graduação

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Resumen

La implementación de actividades en un curso depende de la modalidad educativa, lo que exige una planeación adaptada al contexto de su aplicación. El presente artículo tiene como objetivo describir el desarrollo y evaluación de un curso de regularización en modalidad virtual, en el que se implementaron actividades autogestivas orientadas a contenidos de probabilidad y estadística a nivel posgrado. La muestra incluyó a 132 aspirantes y estudiantes distribuidos en cuatro iteraciones, quienes participaron a través de Moodle, quienes respondieron un cuestionario final que evidenció algunos factores determinantes, como el manejo de la plataforma, la presentación de las actividades, el uso de recursos TIC y la retroalimentación continua. La aplicación de la Investigación Basada en Diseño (IBD) permitió realizar modificaciones progresivas que mejoraron tanto la experiencia de aprendizaje de los estudiantes como su rendimiento académico. El enfoque autogestivo brinda flexibilidad, al permitir a los estudiantes organizar su tiempo y espacio para completar las actividades propuestas dentro de los plazos establecidos. Sin embargo, se identificaron desafíos asociados con la modalidad a distancia, lo que motivó a implementar estrategias adicionales, tales como una mejor planificación y una comunicación constante entre el docente y los estudiantes.

Palabras clave: autogestión, educación a distancia, enseñanza de la estadística, tecnología educativa.

Abstract

The implementation of course activities depends on the teaching modality and how they are designed, which requires planning adapted to the specific context of application. This article aims to describe the development and evaluation of self-managed activities in a regularization course on probability and statistics at the graduate level, delivered in a virtual format. The sample included 132 applicants and students distributed across four iterations. They participated in the course through Moodle and completed a final questionnaire, which revealed several determining factors such as platform management, activity presentation, ICT resources, and continuous feedback. The application of Design-Based Research (DBR) led to progressive modifications that improved both students' learning experiences and their academic performance. The self-managed approach proved to be flexible, enabling students to organize their time and space to complete the proposed activities within the established

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deadlines. However, challenges related to the distance learning modality were identified, leading to the implementation of additional strategies such as improved planning and constant communication between the teacher and students.

Keywords: self-directed learning, distance education, statistics education, educational technology.

Resumo

A implementação das atividades de um curso depende da modalidade educacional, o que exige um planejamento adaptado ao contexto de sua aplicação. Este artigo descreve o desenvolvimento e a avaliação de um curso de tutoria virtual, que incluiu atividades autodirigidas focadas em probabilidade e estatística de pós-graduação. A amostra incluiu 132 candidatos e alunos distribuídos em quatro iterações. Eles participaram pelo Moodle e responderam a um questionário final que destacou diversos fatores determinantes, como gestão da plataforma, apresentação das atividades, utilização dos recursos de TIC e feedback contínuo. A aplicação da Pesquisa Baseada em Design (DBR) permitiu modificações progressivas que melhoraram tanto a experiência de aprendizagem dos alunos quanto seu desempenho acadêmico. A abordagem autodirigida proporciona flexibilidade, permitindo que os alunos organizem seu tempo e espaço para concluir as atividades propostas dentro dos prazos estabelecidos. No entanto, foram identificados desafios associados à abordagem de ensino à distância, o que motivou a implementação de estratégias adicionais, como melhor planejamento e comunicação contínua entre professores e alunos.

Palavras-chave: autogestão, educação a distância, ensino de estatística, tecnologia educacional.

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Introduction

The term "self-management" comes from the Greek "auto," meaning "by oneself," and the Latin " gestio ," which refers to "administration." In the educational context, self-management is understood as the process by which students make decisions about how to direct their learning, in order to improve their knowledge and skills without neglecting the course objectives (Barboza, 2016).

Distance learning programs are designed to allow students to adapt their activities to their personal context. In this sense, self-regulation of time and content becomes essential. Therefore, the inclusion of self-managed courses in these types of programs is key, as it allows students to adjust the what, how, and why of their learning, thus improving their educational experience (Ponce-Ponce, 2016).

With the growth in the range of educational programs available, the need to establish rigorous criteria for the skills students must develop in each educational modality has become increasingly important. Consequently, the design, planning, and implementation of these programs' content must focus on ensuring that, in the case of distance or online education, courses are centered on self-management, allowing students to take full advantage of training opportunities and achieve effective learning.

Distance learning is characterized by creating an environment in which, although students and teachers do not share a physical space, they interact virtually. This facilitates flexible learning by allowing asynchronous content distribution and optimizing the use of Information and Communication Technologies (ICT) (Ponce-Ponce, 2016).

Traditionally, the responsibility for learning was considered to fall exclusively on the teacher and the strategies they used. However, today, it is recognized that this process is a collaborative effort, in which the student, with their prior knowledge, goals, attitudes, and study strategies, plays an active role in knowledge acquisition. In distance education, the teacher acts as a facilitator, providing tools that allow students to manage and regulate their learning process, assuming responsibility for the development of competencies (Muñoz Maldonado *et al* ., 2017).

It is important to highlight that distance education, along with the increasing use of technology, facilitates educational processes, allowing for self-directed learning . This enables students to take control of their education and develop skills such as critical thinking, analysis, and collaboration, which are necessary to achieve the established educational objectives. According to Núñez Naranjo *et al* . *(2021)*, self-directed learning comprises four key stages: foresight, planning, and activation; monitoring and supervision; control and adjustment; and reflection and evaluation.

According to Ramos-Galarza *et al* . (2020), self-management in teaching offers multiple advantages, allowing students to personalize their educational process and adjust it to their own pace and style, which increases their motivation and interest in learning in a more interactive way. The use of technological tools, such as applications and mobile

devices, facilitates more dynamic learning adapted to the reality of the 21st century, by providing immediate access to relevant information.

In this context, this article aims to describe the development and evaluation of self-directed activities implemented in a virtual, graduate-level probability and statistics remedial course. This proposal reflects a self-directed approach that is better suited to a globalized environment, where student-centered teaching is supported by the instructor to create a learning environment that meets current demands.

Methodology

The development of this project was based on the Design-Based Research (DBR) methodology, particularly suited to projects related to innovation in educational technology, due to its flexibility and continuous improvement approach. According to various authors (De Benito Crosetti and Salinas Ibáñez, 2016; Easterday *et al* ., 2018; Guisasola *et al* ., 2021), IBD follows a series of iterative stages (see Figure 1), which are described below.

Figure 1stages of IBD

Source: Own elaboration

1. Problem Analysis and Definition: An initial assessment was conducted to identify the core learning content for the course "Probability and Statistics," part of the Master's in

Science Teaching at the Faculty of Engineering of the Autonomous University of Querétaro. Semi-structured interviews were also conducted with students who had previously taken the course, in order to identify, based on their experience, the key concepts necessary to begin studying the area. This provided valuable information from both the faculty and student perspectives.

2. Development of theoretically grounded solutions: An introductory course was designed for each unit of the "Probability and Statistics" course, with self-directed activities aligned with the specific objectives of each topic. The content was structured and organized so that students, as they progress, can identify their level of mastery and review the necessary prior content to begin each unit, while deepening and expanding their knowledge through the integration of ICTs.

3. Implementation: At the beginning of the unit, students took a diagnostic test as a self-assessment to identify their prior knowledge and areas for reinforcement. Subject activities were then evaluated, relating performance to the level obtained on the test. If necessary, activities were redesigned or adjusted based on the results of previous iterations.

4. Evaluation: The activities developed were administered to the target sample of students, analyzing their consistency and impact on the course objectives. The project was implemented four times with graduate students studying Probability and Statistics. Improvements were introduced in each iteration. The total sample consisted of 132 students enrolled in the course and participating voluntarily, distributed as shown in Table 1.

Table 1 Sample size per iteration

Iteration	Period	Sample size (n)
1	January – June 2022	7
2	July – December 2022	15
3	January – June 2023	12
4	July – December 2023	98
Total		132

Source: Own elaboration

In the first implementation, a qualitative study was conducted with the sample of students. During this stage, a questionnaire was used to understand their perception of the course through specific indicators related to the proposed activities. The context of the

technological tools used was explored, and, if necessary, interviews were conducted to clarify or delve deeper into certain points of the questionnaire.

The perception questionnaire included questions related to the presentation of the activities, their implementation, and their relationship to the ICT resources presented, allowing for an assessment of the students' experience. The objective of the first implementation was to observe whether the integration of ICT resources and self-directed activities in the subject "Probability and Statistics" improved students' understanding.

At this stage, the sample included seven students enrolled in the course during the first semester of 2022. As a result of this iteration, the questionnaire responses were analyzed through a qualitative categorization to detect common patterns and make adjustments based on the results of this phase.

Subsequently, during the second semester of 2022, the sample consisted of the 15 students enrolled in the subject and based on the results of the first implementation, and the diagnostic evaluation in each unit, the students were classified according to their level of prior knowledge into three groups, who were provided with material so that in one week they would level up and be able to continue with the scheduled curricular course.

It is important to note that students were informed that the activities would not affect their performance in the course, given that it was an extracurricular implementation designed to enhance their learning. Starting with the second implementation, some adjustments were made to the activities. For example, the wording of some questions was modified and the total number of questions in the diagnostic questionnaire was increased to twelve exercises, based on observations from the pilot program, to improve clarity and more accurately measure each student's level.

In the second iteration, the sampled students who completed the proposed extracurricular course completed two questionnaires: one on knowledge to assess learning and another on their perception of the course to, if necessary, make corrections to the extracurricular course in accordance with the IBD. The knowledge questionnaire included contextualized questions designed to identify whether the student had understood the concepts studied in each unit, while the perception questionnaire focused on aspects such as the clarity of the presentation of activities, their practical implementation, and the integration of ICTs.

The third implementation took place during the first semester of 2023, and the sample again included students enrolled in the "Probability and Statistics" course. In addition, a

"Statistics and Probability Workshop" was organized, which covered most of the topics studied in this research, aimed at people similar to the target population. Therefore, on this occasion, the sample consisted of 12 people.

In this iteration, prior knowledge was assessed diagnostically before the start of each unit to classify and distribute materials for leveling so students could continue with the course. Similarly to the second iteration, a perception and knowledge questionnaire was administered at the end of the course.

To this point, due to the limited sample size observed in the implementations and the small number of students enrolled in the course, an opportunity was identified to improve and refine the induction course in each unit. To this end, during the fourth implementation, during the second semester of 2023, the scope of the course was expanded, opening it to a broader audience that included not only graduate students but also those aspiring to a scientific postgraduate degree, assuming that these students had already completed their undergraduate studies. Under these conditions, 98 students participated, of whom 23 were enrolled in Statistics or related disciplines at the graduate level, while the rest were undergraduate graduates.

The decision to diversify the student population was primarily intended to obtain a more robust sample that would allow for a more thorough evaluation of the induction course's effectiveness and impact in different academic settings. The same strategy used in previous implementations was followed, which consisted of administering a diagnostic exam and then presenting remedial material based on the results of that assessment.

Results

In the first implementation, carried out during the first semester of 2022 (2022-1), an exit questionnaire was administered. Five of the seven students agreed that the proposed activities included both disciplinary and didactic content, an important aspect to maintain to facilitate the presentation of the material and ensure congruence with the course's curricular objectives. Two students suggested reducing the number of questions in the diagnostic questionnaires (which consisted of 15 random items) as they faced technical difficulties related to connectivity and time, which forced them to repeat the assessments, affecting their results. In response, it was decided to reduce the number of questions for the next iteration. Likewise, six of the seven participants expressed that the ICT resources and teaching

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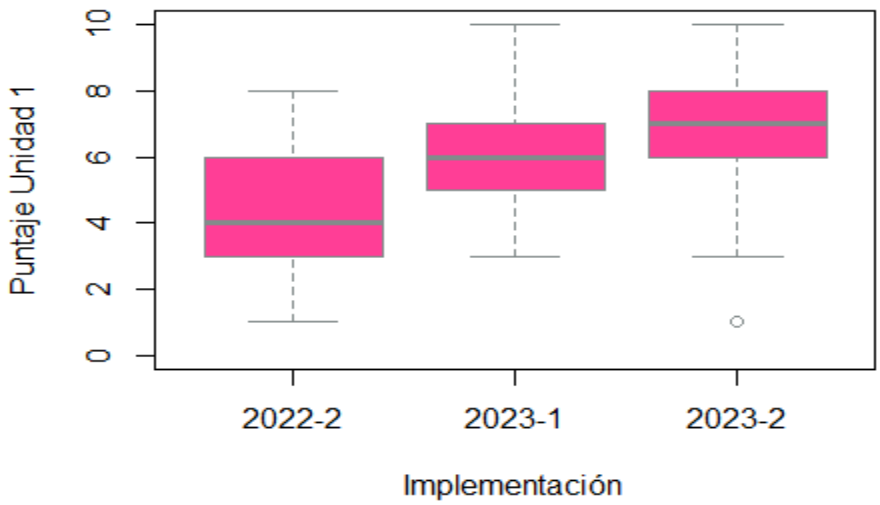
strategies used to open, develop, and close each unit were interesting, innovative, and relevant to learning.

Regarding the relationship between the activities and other subjects, 71.4% of students indicated that the connection with other areas was evident, while 28.6% did not perceive this as the case, attributing this to the context of the diagnostic questionnaire questions. Given the virtual nature of the course, the importance of students feeling supported during the activities was highlighted. In this regard, 71.4% expressed satisfaction with the instructor's feedback and the suggested extracurricular activities.

Overall, students expressed satisfaction with the activities and the course, highlighting the positive impact of the promotion of self-learning. They also demonstrated a high level of engagement with the subject matter, which is relevant to one of the central themes of this project: promoting self-management as a means of fostering learning.

The second implementation took place during the second half of 2022 (2022-2), using a diagnostic questionnaire to evaluate and monitor the improvements made in each iteration. The scores obtained by unit in each implementation were compared. As the design and sequence of the self-managed activities were refined , an increase in the average scores of Units I (Descriptive Statistics) and Unit III (Probability Distributions) was observed in each of the implementations, suggesting a positive trend in the effectiveness of the improvements introduced (see Figures 2 and 4).

Figure 2. Score obtained in unit 1 questionnaire

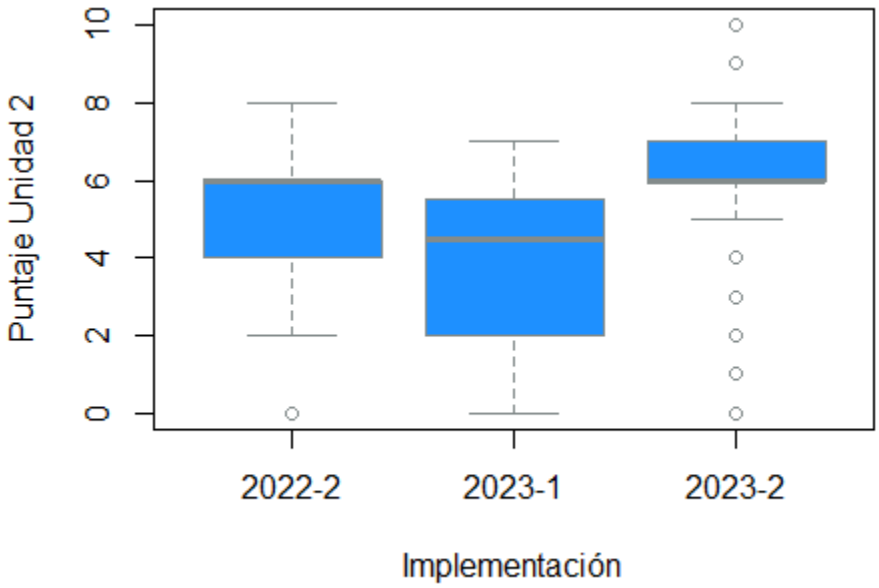


Source: Own elaboration

In Unit II, which focuses on probability topics, a decrease in scores was recorded during the third implementation (2023-2024), along with a greater dispersion in the results. This variability can be attributed to the diversity of the student group participating in that implementation, which included those enrolled in both the course and the "Statistics and Probability" workshop (see Figure 3).

In the fourth implementation (2023-2), the dispersion was even greater, mainly due to two factors: the sample was significantly larger (98 students) and the inclusion of 8th and 9th semester undergraduate students, who may not be as familiar with statistical terms and concepts applied to a context.

Figure 3unit 2 questionnaire



Source: Own elaboration

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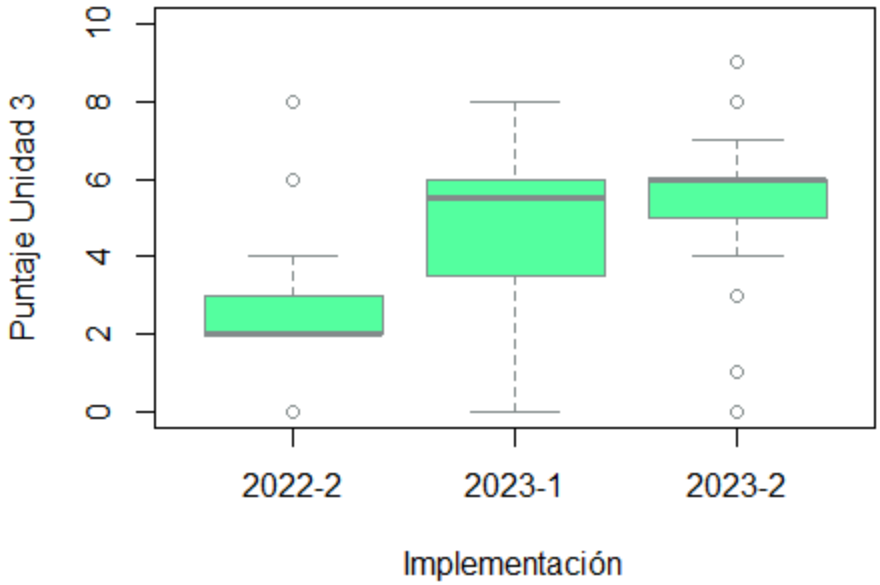
Figure 4unit 3 questionnaire



Source: Own elaboration

These results highlight the importance of considering students' diversity and familiarity with course topics when evaluating and adjusting activities and teaching strategies. The greater dispersion in scores also underscores the need to continue providing feedback during activities to ensure they are accessible and effective for all students, regardless of their academic level or prior experience in statistics.

To determine whether there were significant differences between the means of the different implementations, an analysis of variance (ANOVA) was performed. The results indicated statistically significant differences, suggesting that the modifications made in each cycle impacted student performance. This improvement was also reflected in the final grade point averages, indicating that the adjustments made were effective in optimizing both the learning experience and the academic performance of the participants.

To complete the comparative analysis, the Tukey-Kramer test was applied, given that the assumptions of normality (Shapiro-Wilk test) and homogeneity of variances (Levene test) were met. The ANOVA identified significant differences between the means, with the second semester of 2022 implementation standing out as the only one with a statistically significant difference compared to the others. This is attributed to the fact that, in that iteration, more substantial modifications were introduced, both in the diagnostic assessment items and in the sequencing of the contents. In contrast, the changes made in the third and fourth

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implementations did not generate relevant differences, suggesting that the observed variations could be mainly due to the level of prior preparation of the students.

Discussion

As a result of the application of the IBD and the continuous evaluation process of self-managed activities for the regularization of probability and statistics topics at the graduate level, important findings stand out throughout the four project implementations. The results reflect a positive evolution and allow for relevant conclusions to be drawn. According to Valverde- Berrocoso (2016), the purpose of research such as this is to design, develop, and evaluate proposals that serve as a basis for future projects, identifying transformative elements in educational processes.

The first implementation of the project was crucial for validating the instruments used in the project. A strategy was proposed that required students to dedicate exclusive time to reviewing and solving the activities, which appears to have improved both time management and task commitment. Validation was fundamental to the IBD methodology, providing a solid foundation for improvements made in subsequent implementations.

Throughout the implementations, a progressive increase in student grades was observed, highlighting the importance of adapting the course to their needs and learning styles. ICT-mediated teaching activities, along with the use of web tools, received positive feedback, particularly during the final phases of each unit, when students dedicated more time. In line with Belfiori (2014), ICTs can play a fundamental role in knowledge generation by promoting improvements in the educational aspect, with the potential to capture interest to motivate students and facilitate tutor or teacher support on their path to the expected learning. While the use of ICTs suggests a strong commitment to self-assessment and knowledge consolidation, some resistance was observed toward non-assessable activities, even at the graduate level, highlighting the need to design strategies that maintain student motivation and promote active participation, regardless of whether the activities directly influence their grade.

The analysis of the initial assessment shows that self-managed activities contribute to the leveling of concepts, although their effectiveness varies depending on the subject. While descriptive statistics was perceived as more accessible and intuitive for students, probability topics, especially probability distributions, presented greater challenges. However, an improvement in average academic performance was observed compared to previous

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semesters, largely attributed to the self-assessment and regularization that supported students' progress.

One of the key aspects of this project was the virtual implementation of the remedial activities, which allowed each student to access a flexible and adaptable environment that fostered self-management. This format made it easier for students to organize their time based on the scheduled activities by establishing deadlines to achieve the objectives for leveling in probability and statistics. Self-management requires a commitment from the student, allowing them to complete the course within the established time and take advantage of the benefits of the virtual modality. In line with what Ponce-Ponce (2016) highlights, distance education should focus on building an environment in which teacher-student interaction, although not physical, is supported by virtual connectivity, prioritizing learning-centered training processes and leveraging the flexibility of ICTs. These premises are evident in the results of the remedial strategies, in which virtual activities proved to be fundamental in fostering self-management.

The inherent limitations of the virtual modality must be recognized, especially regarding the interaction between teachers and students, an aspect that can weaken the didactic contract. Therefore, it is important to emphasize maintaining constant and active feedback and communication to strengthen educational support.

Conclusions

The inclusion of a larger group in an iteration of the remedial course was beneficial as it provided a diverse and comprehensive view, identifying performance patterns that might have gone unnoticed in smaller groups. Furthermore, the participation of recent bachelor's degree graduates highlighted the flexibility of the self-managed approach .

Early identification of students who required additional support in probability and statistics through diagnostic assessments facilitated their placement and tailored their follow-up to the course curriculum, thereby meeting the established objectives. It is important to emphasize that, in graduate studies, students must possess solid disciplinary knowledge and practical skills that allow them to adequately address the course content. Therefore, it is essential to develop a deep understanding of the concepts in students, not only with the goal of passing the course, but also to acquire meaningful and lasting skills.

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To enhance both academic performance and student satisfaction in virtual education, it is essential to emphasize learning acquisition through strategies that foster self-management among students in this modality and also promote motivation throughout the course. This aspect is especially relevant in graduate settings, where a higher level of individual commitment is required.

Finally, it is essential to promptly identify students experiencing difficulties. In this process, the teacher's role is key, as they can implement support strategies and ongoing communication that help overcome the limitations inherent in virtual education. Furthermore, detailed and periodic review of proposed activities should be a systematic practice, ensuring completion of assignments and achievement of learning objectives. The balance between student self-management and active teacher support is essential for the success of virtual courses .

Future lines of research

The results obtained in this study open up several possibilities for future research on self-management in graduate students, particularly in mathematics-related courses. This research could explore its implementation in more depth and be complemented by new projects that explore how to increase active participation in virtual environments, especially in ungraded activities geared toward meaningful learning.

In this sense, exploring how the self-management approach can be adapted and implemented in different educational modalities and applied to areas other than probability and statistics—considering the specificities of each group and discipline—would allow for the development of innovative methodologies to identify and promptly support students with the greatest learning difficulties.

Furthermore, it would be important to design and evaluate strategies that increase active participation, foster motivation, and promote meaningful learning, regardless of whether the course is curricular or extracurricular. In this regard, we propose incorporating elements such as gamification, self-assessment, and group feedback to analyze their impact on student engagement in various educational settings.

Finally, it is important to conduct longitudinal studies that allow us to observe the impact of the acquisition and development of self-management skills on both academic and professional performance of students at later stages.

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These lines of research not only broaden the scope of this study, but also contribute to the consolidation of a theoretical, methodological and practical framework for self-management, strengthening its relevance at different levels, contexts and disciplines .

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