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Research Insights
Изследователски проникновения

A RECOMMENDATION METHOD TO ADAPT CURRICULUM AND IMPROVE LEARNERS PERFORMANCE

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Abstract. Higher education curricula have evolved to incorporate technologies, but adaptive models continue to yield limited results. This study proposes a recommendation method for an adaptive curriculum that improves student performance. The research followed a mixed-method approach to programming courses at the Salesian Polytechnic University. The average population is 320 students and between 7 and 10 tutors each academic period. Survey techniques were applied to teachers and students between October 2024 and March 2025. The results show that 81% of students on average significantly improved their performance over seven academic cycles. Similarly, four of the seven teachers (57%) expressed a favorable perception of the model's implementation. Despite these results, the sample size and KMO value suggest caution. A control group was omitted to ensure fairness in learning, which limits generalizability. However, the results suggest that the model is transferable to other courses, potentially incorporating artificial intelligence to enhance its socio-professional relevance.

Keywords: adaptive model; higher education; teachers' perceptions; learner's performance; recommendation method

Introduction

A fundamental principle for any educational institution aspiring to excellence is the need to adapt processes that improve learning. Currently, with the rise of new technologies, the urgency of having adaptive mechanisms that improve curriculum content is a recurring theme in educational research. Although research evidence suggests solutions that utilize advanced technological infrastructures, such as large-scale data analysis and recommendation-oriented computer systems (Luo et al., 2025), there remains a need to focus on teacher experience, knowledge extraction from classroom observations, and collaboration among teachers. In situations of low university performance, collaborative strategies among teachers are required, tailored to the specific needs and contexts of the student body. Therefore, it is essential for researchers in this field to examine the factors that impact the educational process, from curricula to the methods by which learning objectives are achieved.

The curriculum of a subject is a significant area of study, as it involves examining the logical, theoretical, and philosophical sequence of the content that comprises an educational experience (Biggs & Tang, 2012). In effect, the curriculum is the set of curricular objectives, methodologies, learning, assessment, and resources developed by the educational institution in accordance with standard educational regulations (Print, 2020), for what is proposed as study in specific environments. Therefore, students require guidance from teachers and personalized recommendations to enhance the effectiveness of their learning process. The role of teachers is to help students explore available resources, make informed decisions, and receive timely feedback. This approach effectively promotes personalized learning while minimizing cognitive load, reducing learning time, and simplifying understanding of course material (Luo et al., 2025)supporting personalized learning effectively necessitates recommending sequences of learning items that maximize learning efficiency while minimizing cognitive load, all tailored to the learner's goals. These recommendations must account for the prerequisite relationships among learning items and the learner's characteristics to create highly adaptive learning paths. Current methods encounter two primary challenges in recommending such adaptive learning paths. Firstly, they fail to formulate reasonable learning goals by integrating established learning principles. Secondly, they struggle to balance the trade-offs between improving learning performance (P.

In 2019, the Salesian Polytechnic University of Guayaquil, Ecuador, presented faculty members with a new proposal for collaboration among professors who teach the same subject. It consisted of improving curricula and content to improve student academic performance. Thus, a collaborative effort was developed, establishing research-based strategies that respond to the demands of higher education in the era of emerging new information technologies. The objective was to develop processes of change, curricular innovation, and optimization of classroom practices, consistent with the experience of teachers, the use of technologies, and the generation of teaching materials that reinforce assessment processes. It also sought to identify activities in the curriculum that required changes to improve student participation and academic performance. Likewise, it sought to provide feedback on teachers' actions as a mechanism for adapting to curriculum planning, thereby resolving situations of risk or student dropout over time.

The integration of technologies into the learning process, such as models based on innovative technologies, artificial intelligence, computer systems, or expert programs, often yields encouraging results (Abuhussein & Badah, 2024). However, there is a gap in research on non-technological recommendation methods that leverage teachers' experience and feedback based on data and adaptive processes in accordance with the knowledge gained at that time. Although recommendation systems are used to guide educators, despite the rise of technology, teachers' experience and knowledge remain important and are often underutilized.

The objective of this study is to develop an adaptive educational curriculum model to improve student performance through a collaborative approach between teachers and students. This paper is structured as follows. First, the current state of the art in the field of study is presented. Next, the methodology followed is detailed. Immediately following these are three sections presenting the research phases, the recommendation method for teachers, and the design of data collection instruments. Finally, the last three sections present the results, their corresponding discussion, and the conclusions.

State of the Art

In the age of data, the personalization of learning paths is a topic that addresses interest in the field of data storage, analysis, and processing, as well as student progress, based on sources such as electronic platforms (Luo et al., 2025)

However, another prominent area of research is the development of effective teaching strategies based on a teaching model that facilitates assessment in line with curriculum objectives and enhances student satisfaction. At the same time, the effects of strategies such as gamification, project-based learning, serious games, flipped learning, collaborative teamwork, equity, and inclusion are being explored to determine whether the strategies applied improve student motivation, skills, commitment to study, continued participation, and academic performance (Basthomi et al., 2025).

Firstly, teachers' concern about their role as tutors and the impact of their teaching performance within the educational institution is evident (Huang & Liu, 2025). In fact, there is already extensive research on teacher identity (Abuhussein & Badah, 2024), teacher leadership (Goetzke & Lumpe, 2025), and the development of professional competencies (Godsk & Møller, 2025). This highlights a profound shift in the way educators understand and engage with emerging technological trends, particularly digital educational tools (Maluleke, 2024). Additionally, the knowledge that teachers acquire when they design effective educational experiences during their teaching careers is recognized as a crucial factor that positively impacts the learning process of students (Rigdel & Thapa, 2024).

Secondly, the conclusions on effective curriculum management are noteworthy (Combrinck, 2024; Srivastava et al., 2024). There is also a body of knowledge related to pedagogically developed strategies that focus on personalized and secure learning, moving from theory to practice (Alhowail & Albaqami, 2024). In addition, actions to improve the curriculum are proposed (Rueda et al., 2024), indicating a commitment to implementing innovative practices in the classroom. For example, several studies have demonstrated the effectiveness of Zimmerman's cyclical model of self-regulation (Tzeng et al., 2024), which focuses on students' self-regulated learning, in establishing a clear framework for action and, with it, recommendations based on observations. Additionally, there is interest in learning that fosters procedural, social, and empathetic skills in groups, promoting analysis, reflection, and group feedback.

Thirdly, the findings emphasize the use of technologies for the adaptation and recommendation of curricular content, offering teaching resources adapted to student performance (Cruz-Bohorquez et al., 2024), while improving the learning experience with appropriate course design (Pacala, 2024), and integrating open educational resources (Bradshaw et al., 2024). The underlying objective is to improve academic understanding of topics and concepts, as well as to improve research skills (Ban et al., 2024; Castro et al., 2024), to ensure student continuity, preventing school dropout, as well as situations of risk or dissatisfaction in learning experiences (Mills & Rao, 2025).

Methodology

An applied research methodology with a mixed approach is developed through a quasi-experimental study. Based on a sequential-deductive design, a set of five work phases is established for developing the recommendation method, guided by an approach based on design science research theory (Kuechler & Vaishnavi, 2008).

The study applies the iterative method defined by Vaishnavi et al. (2004), which follows a straightforward procedure: problem statement, solution strategy, proposal/prototype development, evaluation, and conclusion. Two research questions are posed, RQ1: What recommendation method has been designed to support teachers in accordance with an adaptive curriculum model? RQ2: What is the perception of teachers with the implementation of the recommendation method?

Study Participants

This approach was implemented in the Programming course at the Salesian Polytechnic University, a common subject for all first-year students from various engineering specialties, including Computer Science, Electrical Engineering, Electronics, and Automotive Engineering. An average of 320 students participate each year, spread across 8 to 10 courses per semester. The teaching staff, a dynamic working group, integrates new professors each semester, who participated in the project's work phases from the beginning. Depending on the semester's offerings, between 7 and 10 tutors participate (each teaching up to three courses), whose continuity depends on academic needs, and who may be ratified or renewed each semester. The research was conducted between October 2024 and March 2025.

In the first phase, the seven teachers assigned to the eight courses were invited to attend classroom training and receive an explanation of the adaptive curriculum model methodology and its recommendation method. In the second phase, at the end of the course, a survey was conducted to collect data from teachers and measure their satisfaction. A questionnaire with a mixed-method design was used, consisting of six open-ended questions and eight closed-ended questions.

The data collected was analyzed using various software tools and techniques. Gretl version 2024d was used to calculate Cronbach's alpha using a custom script to assess the internal consistency of the closed-ended survey questions. For exploratory factor analysis, JAMOVI 2.6.26 was used, employing the minimum residuals extraction (SSE) method and Varimax rotation to determine the independent factor. The number of factors was determined based on Kaiser's criterion, retaining factors with eigenvalues greater than 1. Finally, Python algorithms in Google Colab allowed for initial data cleaning and the generation of bar charts for visualization at the end of the descriptive statistical analysis.

Research phases

At the beginning of an academic period, during the "awareness of the problem" phase, faculty members analyze the previous period's grades and relevant literature to improve the curriculum and provide information to new Programming course tutors for the next period.

In the "suggestion" phase, the difficulties encountered by students in the previous academic period are identified and compared with existing gaps in the scientific literature. Based on collaboration with teachers, recommendations are compiled to enhance the curriculum content.

In the "development" phase, improvements to the curriculum are implemented. During the course, based on observations made by teachers, the results of student learning assessments, and student feedback, decisions are made about further adaptations, including the renewal, updating, or replacement of learning activities, as well as the optimization and improvement of the recommendation method for teachers.

In the "evaluation" phase, the results obtained (changes in learning trajectories, effective feedback, and performance improvements) are analyzed to adjust subsequent activities on a cyclical basis until the end of the period. The "conclusion" phase identifies the most relevant recommendations to be considered for improving the curriculum in the following period (Fig. 1).

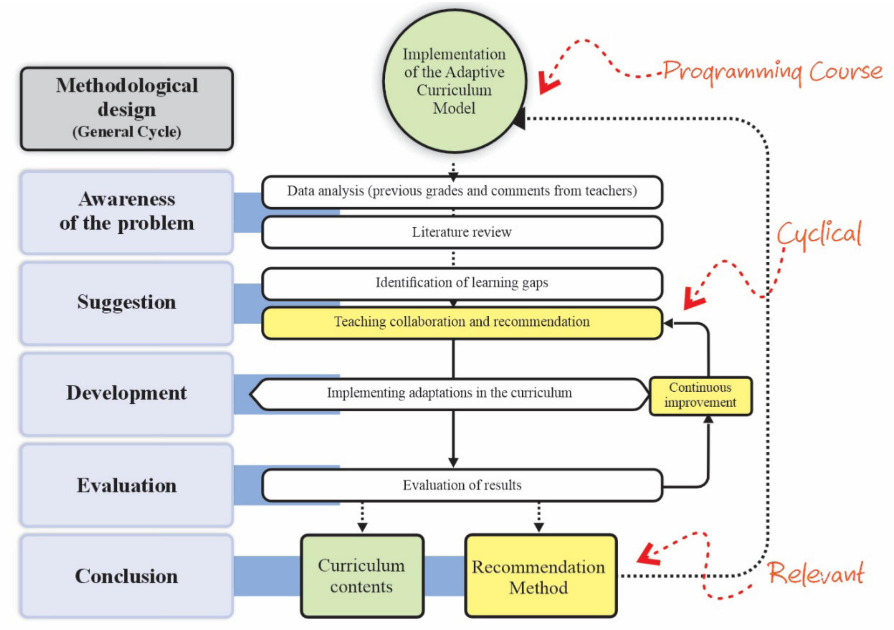

Figure 1. Work phases for developing the recommendation method, guided by a design science research theory

The recommendation method for teachers

To address RQ1, the recommendation method focuses on enhancing the effectiveness of the teaching and learning process by utilizing student feedback and performance in activities. A detailed approach is provided for developing a recommendation method based on the adaptive curriculum approach. Recommendations are suggested for teachers to adopt based on their previous course experience, which is established through the feedback received. For a detailed recommendation method, three aspects are defined: 1) Additional explanation. Students receive additional explanations to help clarify concepts and resolve doubts. This aspect recommends that teachers be more flexible when presenting activities and improve the quality and performance of their teaching. 2) Extension of the deadline. It is recommended to extend the deadline for students who are struggling. This is a key point to consider when recommending adjustments to deadlines or being flexible with students. 3) Recommendations based on performance. If students do not reach the passing threshold (for example, a grade higher than 0.7 or 70% of the grade), it is necessary to suggest recommendations to the teacher on how to adjust teaching (strategies or methodologies) to improve performance. The method follows a series of structured steps.

Step 1: Data collection. This focuses on two points. The first is student performance. Each student's grades and performance in activities are recorded and stored. The second is comments and feedback. Feedback from students on activities is collected.

Step 2: Identify difficulties. This focuses on three points. The first is the identification of problematic activities. Grades are used to identify activities in which students have difficulties. The second is pattern analysis. Patterns in low grades are studied to identify recurring areas of difficulty. The third is the percentage of incomplete activities. The percentage of incomplete activities is calculated to determine if there is a widespread problem in the curriculum.

Step 3: Generate recommendations. This is organized into three aspects, each with two points. The first aspect addresses additional explanations for an activity. As a first point, if an activity has a generally low performance, the teacher is recommended to provide feedback through additional explanations. The second point focuses on re-evaluating activities, which involves revising or modifying them to make them more understandable or better suited to the needs of the students.

The second aspect focuses on adjusting the plan. The first point focuses on extending assignment deadlines; if many students are likely to fail, teachers are advised to consider extending them. The second point refers to modifying the content of the activity. If a high percentage of students fail an activity in the curriculum, the teacher is advised to review and adjust the content to make it more accessible.

Finally, the third aspect refers to personalized recommendations. The first point focuses on adapting curricular changes based on student performance, with personalized suggestions on teaching strategies that could be more effective. The second point is continuous and specific feedback to students to guide them in their improvement process.

Step 4: Implementation and follow-up. This focuses on three points. The first is the application of recommendations. Teachers must apply the recommendations in their teaching practices and in the design of the curriculum. The second is the monitoring of results. Monitoring is conducted to evaluate whether the recommendations have had a positive impact on student performance. The third is the adjustment of the recommendation method. Based on the monitoring results, the recommendation method is adjusted to enhance its effectiveness.

The following is an example of how to structure a recommendation for a teacher using the data and method mentioned above. Problem identified: 55% of students have grades below 0.7 (equivalent to 70% of the mark) in Activity 2 (using this activity as an example). Recommendation: Provide additional explanations. Offer tutoring sessions or additional materials to help students better understand the content of Activity 2. Extend the deadline. Consider extending the deadline for Activity 2 to give students more time to complete the work. Review the activity. Assess whether Activity 2 is too complicated or if there are any concepts that need clarification.

During the course, teachers and students provide feedback that guides the learning path, understood as an experience proposed by the adaptive model. To ensure an adequate educational process in the courses offered, recommendations and messages, as well as grade ranges, are reviewed on an ongoing basis in accordance with relevant institutional provisions.

Design of data collection instruments

To deal with RQ2, the reliability analysis of the survey establishes relationships between variables and dimensions through each question. Questions Q1 to Q8 relate to a study variable (Table 1).

Table 1. Variables and associated dimensions in the survey

Question	Variable	Dimension
Q1	Frequency of assigning new subjects	Stability of the teaching role
Q2	Satisfaction with having initial curriculum support	Acceptance of resources
Q3	Participation in tutor training	Training in curricular resources
Q4	Perceived benefits of curriculum standardization	Curricular uniformity
Q5	Assessment of curriculum uniformity	Standardization of the learning experience
Q6	Feedback method	Formative assessment strategy
Q7	Usefulness of recommendations for adaptation	Effectiveness of feedback for continuous adaptation
Q8	Perception of teacher support for adaptation	Support for curricular adaptation

Questions P3 (Participation) and P6 (Feedback) use a scale with few options, while the rest of the questions use a five-point Likert scale. The reliability of the survey was determined by calculating Cronbach's alpha, obtaining an alpha of 0.728. Questions P1, P2, P3, and P6 were discarded to improve reliability to 0.884, confirming a solid, consistent, and reliable interpretation of the items involved. Although the number of factors depends on Kaiser's criterion, a KMO of 0.5 (minimum acceptable) was achieved due to the small sample of participating teachers. Exploratory factor analysis revealed a single main factor, supporting the one-dimensionality of the study and the solid validity of the survey, with high factor loadings on questions 4 (standardization), 8 (teacher support), and 5 (importance of common resources), and moderate loadings on question 7 (usefulness of recommendations), with 0.928, 0.928, 0.886, and 0.619, respectively. This confirms that the four items measure the same construct ("Adaptive Curriculum Model"). Finally, the results of the questions most relevant to this study were represented in vertical bar graphs.

Results

In relation to RQ1, the results have shown that the recommendation method designed to support teachers was based on a collaborative and continuous process of analysis, observation, and interpretation of student assessment results by the teachers themselves.

The analysis of performance patterns throughout each period, structured into two assessments (one midway through the course and one at the end), showed a significant improvement in student performance. In a programming course during the period between October 2021 and March 2022, the trend was that students were motivated before the first exam of the course (red dot, left figure) and again before the final exam (red dot, right figure), as shown in Fig. 2.

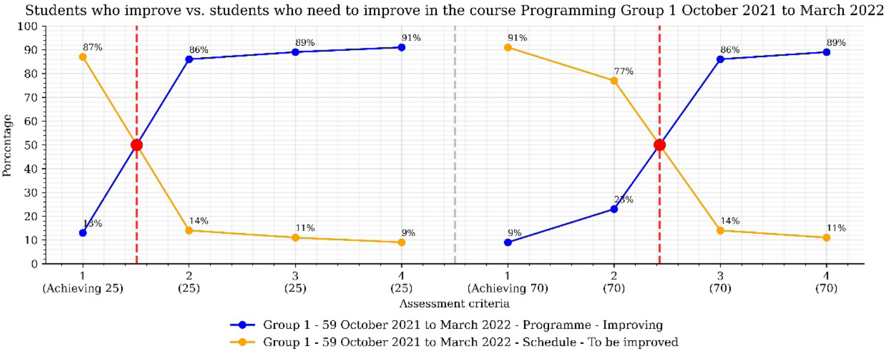

Figure 2. The figure on the left shows the students' performance before the first exam, while the figure on the right shows their performance before the final exam

For the period from October 2023 to March 2024, the performance pattern (refined recommendation method) showed a remarkable transformation. The disappearance of the critical inflection point (red circle) in the second half of the period was a significant indicator of the effectiveness of the strategies applied. A more linear and sustained trajectory in performance improvement can be observed throughout the period. The percentage of students who improved significantly (blue line) remained consistently high from the beginning of the period, without a sharp drop after the first assessment that was evident in the previous period. Similarly, the percentage of students with minor improvement (orange line) remained at low and relatively stable levels (Fig. 3).

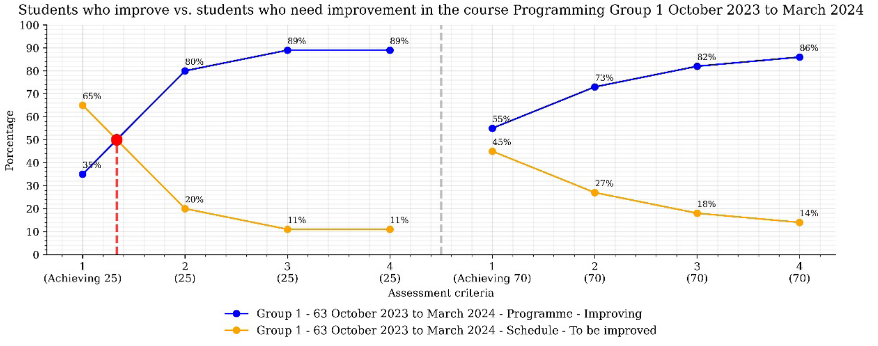

Figure 3. The figure on the left shows the students' performance before the first exam. The figure on the right shows the students' more consistent performance before the final exam

This result demonstrates the effectiveness of teacher supervision, grade analysis, curriculum adaptations, and teacher motivation in improving student performance and participation in each planned activity.

Regarding RQ2, the items with the highest scores (Q4, Q5, Q8) focus on structured support for teachers. For teachers, the recommendation method is only effective if it is backed by a common and significant base of resources and by the support and interest of their peers in applying the model. The success of the recommendation method is influenced by the environment in which it is implemented. The overall favorable perception is 4.14 on a scale of 5 according to the composite score (Q4+Q5+Q7+Q8)/4). The standardization achieved and the support provided to teachers are the basis for a recommendation method to be applicable and accurate.

Question 4, focused on agreeing with the content of the base classroom, shows that 57% completely agree and 43% agree. Meanwhile, in question 5, which focused on the importance of the recommendations provided for adapting changes to the course based on student grades, the results showed that 57% found it very useful or extremely useful, while 43% found it moderately useful (Fig. 4).

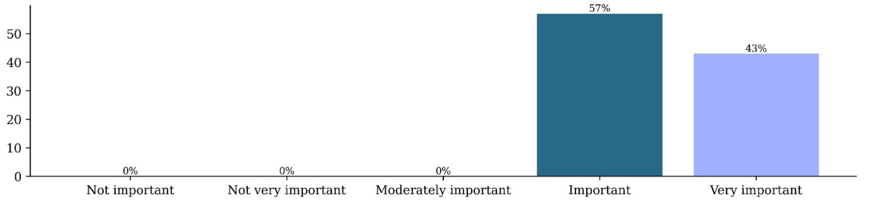

Figure 4. Percentage responses to question 5 of the professor survey

Question 7 asks: Have the recommendations provided for adapting changes to the course based on student grades been helpful in improving their performance? The results showed that 57% find it very useful or extremely useful, while 43% find it moderately useful. These results are presented in Fig. 5.

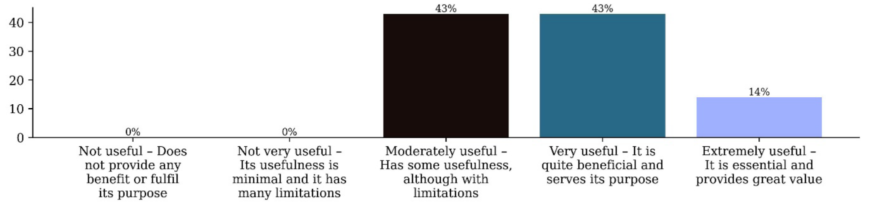

Figure 5. Percentage responses to question 7 of the professor survey

Question 8 inquired about the support provided by teachers as a method of recommending course content adaptations based on students' grades. The results show that 57% consider it very useful or extremely useful, while 43% consider it moderately useful. These results are presented in Fig. 6.

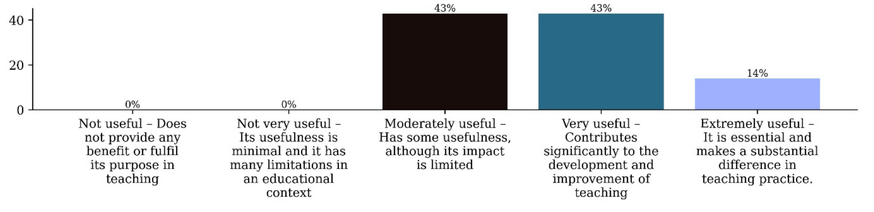

Figure 6. Percentage responses to question 8 of the professor survey

In addition, the records of students who passed and failed from October 2021 to March 2025 (during the application of the model) in the Programming subject were analyzed. The comparative bar chart illustrates the evolution of the percentage of students who passed and failed throughout these academic periods after adaptations to the curriculum and the integration of a recommendation method for teachers that improves student performance, as shown in Fig. 7.

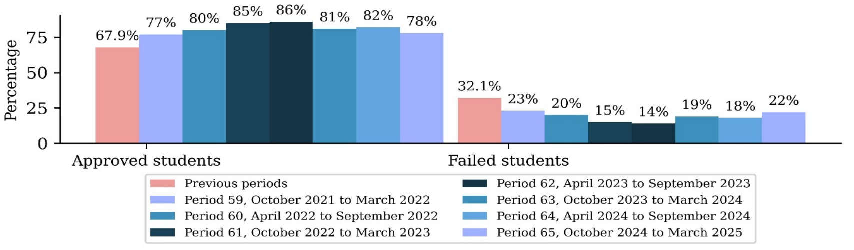

Figure 7. Percentage of students who passed and failed in the academic periods prior from October 2021 to October 2024

Discussion

The recommendation method designed to support teachers is fundamentally based on a collaborative and continuous process of analysis, observation, and interpretation of student assessment results by the teachers themselves, as recommended by G. Luo et al. (2025). Although the method is based on the systematic collection of data on student performance through various quantifiable assessment activities, one limitation of the study focuses on the participation of educators in the management of technologies, their use, and their generalization to other courses. The results show improvements in the way students actively participate in high-level cognitive learning activities, as well as promoting better interaction using the appropriate technology, consistent with Godsk & Møller (2025) work.

Teachers manage this collection and essentially process the assessment results to identify each student's strengths and weaknesses. Another limitation found relates to the frequent turnover of teaching staff, since the adaptive curriculum is designed by professional experts who, in many cases, are the most suitable teachers and require continuity in their teaching roles, according to Goetzke & Lumpe (2025). In addition, ongoing processes are established to collect data on teachers' experiences in developing the course. Although the number of teachers who wish to make changes is limited, this allows for reflection on effective changes to the curriculum and its resources, as mentioned by Pacala (2024). The results may have significant implications for curriculum design, teaching techniques, the development of effective open educational resources, and support services aimed at fostering a positive learning environment and promoting students' overall development, in line with Bradshaw et al. (2024).

Despite the results, the sample size of teachers and the KMO value suggest caution. In a quasi-experimental design, a control group was omitted to ensure fairness in learning; however, this and the use of ad hoc instruments limit generalization, allowing for future replications in broader and more controlled contexts.

However, considering students' changing needs, there is a need for an effective model of curriculum adaptation and a recommendation method for teachers based on those needs, to empower teachers to lead agile adjustments and analytical tools that integrate new technologies and digital skills into teaching, as stated by Castro et al. (2024).

In other words, the results also reveal design implications for academic authorities, based on the information extracted from the learning outcomes and the information provided by tutors based on their acquired experience. In this way, continuous analysis and the inclusion of all relevant teachers enable course sequences to be updated, students to be guided, courses with risk situations to be identified, and possible adaptation measures to be proposed. Finally, educational institutions refine their plans to create more coherent and balanced training pathways, effectively managing the learning trajectory. in alignment with Srivastava et al. (2024).

Conclusions and future work

This article presents the development of a recommendation method for university teachers that complements an adaptive curriculum model, tailored to student performance, based on a collaborative approach that leverages the collective experience and knowledge of teachers. The case study is the first-year engineering programming course at a polytechnic university in the city of Guayaquil, Ecuador. The analysis is based on grade data, tutor observations, and learning outcomes achieved by students throughout the activities planned in the course.

The recommendation method allows for real-time adjustments during the course and improves student learning. This optimizes the ability to provide specific guidance to teachers, recommendations to tutors, and feedback to students (both individually and as a group), facilitating preventive monitoring. As a result, an improved educational experience is created that guarantees the success of the training process in the courses taught. The implementation of the adaptive model and the recommendation method for teachers have resulted in a significant reduction in the percentage of students at risk and academic dropouts in subsequent academic periods. Evidence of a cyclical curriculum optimization process stands out, demonstrating the effectiveness of the method. This has allowed teachers to respond proactively to student needs each semester.

Finally, the integration of technologies in the development of activities and the use of open educational resources have enabled university teachers and/or tutors to provide guidance. In this way, they can generate proposals that materialize in activities and spaces, resulting in more effective recommendations. Over the last seven academic semesters, the average percentage of students passing reached 81%, while the percentage of students failing fell to 19%. Additionally, four out of seven teachers (57%) involved in the most recent period reported a positive level of satisfaction with the experience, suggesting support for the team of tutors in future courses by identifying strategies to improve their perception.

Future work will focus on supporting teachers in developing strategies for curriculum improvement. To this end, the proposed model and ICT will be used, integrating the potential of artificial intelligence under a socio-professional relevance approach.

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