



Understanding student motivation and self-efficacy in differential calculus: Evidence from a technology-based learning approach

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ABSTRACT

The present study analyzed student perceptions of an alternative educational modality for the teaching of differential calculus at an Ecuadorian university. A 20-item questionnaire was applied to 70 engineering students, evaluated by exploratory and confirmatory factor analysis, and complemented with multiple regression models and student's t-tests. The results confirmed a four-factor structure: teaching modality and experience, practices and resources, theoretical classes and demand, and self-efficacy and academic performance. The model showed adequate fit and validity indices, consolidating the relevance of the instrument. Likewise, self-efficacy emerged as the central factor, both for its predictive role in the other components and for being the aspect most highly valued by the students. These findings show the relevance of considering organizational, methodological and motivational dimensions in the design of innovative pedagogical proposals to strengthen learning in highly demanding subjects such as differential calculus.

Keywords: alternative educational modality, academic motivation, differential calculus, factor analysis, self-efficacy, engineering

INTRODUCTION

Differential calculus teaching in higher education faces persistent challenges that limit students' deep understanding. Research has shown that traditional methodologies, which focus on theoretical exposition and the resolution of routine exercises, reduce the development of critical skills and the practical application of mathematical concepts (Alabdulaziz & Higgins, 2025; González, 2025). This approach generates a disconnect between academic content and the demands of the real world, leading to disinterest and learning difficulties.

Differential calculus also represents a critical barrier for engineering students, not only because of its level of abstraction and formalism, but also because of the lack of adaptation of teaching strategies to the needs of the 21st century (Bressoud et al., 2015; Zakariya & Adegoke, 2024). Despite advances in active

methodologies and educational technologies, this subject maintains high rates of failure, desertion and demotivation, especially in environments where expository instruction predominates (Bressoud, 2015). This scenario raises the need to rethink pedagogical models, integrating components that strengthen both the cognitive and the motivational and emotional dimensions of learning (Bandura, 1997; Deci & Ryan, 2013; Elmi, 2020).

The literature has indicated that factors such as self-efficacy, perceived teacher support and active student engagement are significantly correlated with motivation and achievement in mathematics (Hammoudi & Grira, 2022; Segarra & Cabrera-Martínez, 2024; Usher & Pajares, 2009; Zimmerman, 2010). In this sense, self-determination theory posits that motivation is enhanced when students perceive autonomy, competence and positive social relationships (Deci & Ryan, 2013; González, 2025; Singun, 2025). Complementarily, self-efficacy theory argues that beliefs about one's ability to solve mathematical tasks directly influence persistence and academic performance (Bandura, 1997).

To respond to these challenges, innovative pedagogical approaches have been proposed that integrate active and contextualized strategies, such as problem solving, project-based learning and the use of interactive technologies (Husin et al., 2025; Tsamir et al., 2006). These methodologies foster autonomy, stimulate intrinsic motivation and facilitate the transfer of knowledge to practical situations (González, 2025; Wang et al., 2022). However, their widespread adoption faces obstacles related to teacher training, resistance to change and lack of adequate resources, which demands institutional commitment to transform the teaching of differential calculus in higher education (Husin et al., 2025).

Along the same lines, pedagogical proposals have emerged that combine theoretical classes, experimental practices and digital tools such as MATLAB or Desmos, in order to promote more meaningful and contextualized learning (Chechan et al., 2023; Song et al., 2018; El-Thalji, 2025). These modalities seek to activate self-regulation processes and stimulate metacognitive skills through collaborative environments, showing promising results in science and engineering education (Geng & Su, 2025). However, their effectiveness depends to a large extent on the quality of teacher implementation and student acceptance.

However, despite the growing body of research highlighting the importance of active methodologies, educational technologies, and motivational factors in the learning of calculus, there is still limited empirical evidence examining how students perceive integrated alternative educational modalities that combine technological tools, academic support structures, and differentiated teaching roles. In particular, few studies have focused on validating measurement instruments that capture students' perceptions of such comprehensive models in highly demanding subjects like differential calculus, especially in Latin American higher education contexts.

In response to this gap, the present study aims to analyze student perception of an alternative educational modality in differential calculus that incorporates the use of MATLAB and a structured system of academic accompaniment, through the psychometric validation of a questionnaire around the identified factors. For this purpose, the following research questions are posed: What factorial structure underlies student perceptions of the alternative educational modality? What predictive relationships are established between the identified factors? How are student ratings distributed according to the different factors of the model? Are there significant differences in the mean scores between factors, according to Student's t-test?

THEORETICAL FRAMEWORK

Teaching modality and teacher experience are key variables in students' perceptions of the quality of the learning process. Research has shown that methodological clarity, coordination between teachers and transparency in assessment directly influence satisfaction and academic performance (Zee & Koomen, 2016). In contexts of innovation, hybrid modalities or with several teaching actors require adequate pedagogical articulation, as coordination and communication between participants ensures coherence in the educational process and facilitates collaborative work (Hattie, 2009). Likewise, the perception of the teaching experience is associated with the trust that students place in teaching and with their willingness to face highly demanding subjects, such as differential calculus.

Academic practices and learning resources represent a second fundamental axis in the student experience. Recent studies show that active learning and access to relevant materials enhance comprehension and retention of content compared to modalities focused exclusively on lectures (Freeman et al., 2014). In addition, the personalized attention of the practicum teacher, the adequacy of time allotted and the quality of materials significantly impact academic engagement (Meng & Zhang, 2023). In this sense, a positive learning environment in practices allows the consolidation of theoretical knowledge and its transfer to applied contexts, increasing the relevance of the course.

The assessment of lectures is linked to the perception of the quality of teaching and the appropriateness of the level of demand. Factors such as clarity of exposition, opportunities to resolve doubts and coherence between content and assessment are determinants of the student experience (Eccles & Wigfield, 2002). Meta-analytic research shows that teacher clarity and effective feedback have a significant effect on academic performance (Hattie, 2009). Likewise, a balanced level of demand, which challenges the student without creating overload, promotes more meaningful and sustainable learning.

Finally, Bandura's (1997) theory of self-efficacy posits that perceptions of personal competence influence motivation, persistence and academic achievement. Empirical evidence confirms that students with higher levels of self-efficacy develop better study habits, face challenges with greater confidence and achieve higher grades (Brashi, 2022). Moreover, self-efficacy has been found to act as a mediator between educational resources and performance, establishing itself as a key predictor in higher education (Schel & Drechsel, 2025; Xu, 2024). In the case of differential calculus, which demands a high cognitive effort, strengthening self-efficacy is essential to ensure students' academic success.

PREVIOUS STUDIES

Recent research has pointed out the need to integrate technological tools, active learning strategies and motivational approaches that enhance both technical skills and student participation and engagement in mathematics courses in higher education (Alé & Arancibia, 2025; Bonilla et al., 2024; Mohammed et al., 2013). This context shows the urgency of rethinking teaching methodologies towards models that favors conceptual understanding, the resolution of complex problems and the development of transversal competences.

In the field of instrument design, Bonilla et al. (2024) developed and validated a questionnaire to measure student perception of learning differential equations with software support, guaranteeing its validity and reliability through psychometric methods. Such contributions are relevant for assessing the effectiveness of innovative approaches and understanding students' learning experiences more accurately.

Several studies have explored the impact of using MATLAB in mathematics education. Researchers Mohammed et al. (2013) reported improvements in accuracy and efficiency in solving mathematical problems, while Alé and Arancibia (2025) highlighted that the tool favors the visualization of abstract concepts, problem solving and student self-confidence. In a complementary way, Song et al. (2018) showed that the incorporation of simulations and practical exercises with MATLAB strengthens the understanding of theoretical principles and promotes active learning in engineering.

Beyond the technological component, other research has highlighted the importance of motivational and emotional factors in learning calculus. Huang and Lin (2017) designed an instrument to measure motivation in university calculus courses, identifying four core dimensions: self-confidence, value, enjoyment and interest. Their findings showed that these variables significantly influence academic engagement and performance. Likewise, innovative approaches such as the one proposed by Pedersen et al. (2016), through the educational game DiffGame, showed that gamification favors concept retention and enhances the learning experience, offering an attractive alternative to traditional methods.

Taken together, these findings support the relevance of exploring alternative educational modalities that combine the use of specialized software with active, motivational and academic support strategies. These proposals strengthen conceptual understanding, increase motivation and favors student commitment, providing empirical evidence that can guide the design of more effective methodologies for the teaching of differential calculus in higher education.

METHODOLOGY

This study was developed under a quantitative explanatory-correlational approach, with the purpose of identifying the underlying structure of student perceptions of an alternative educational modality in the teaching of differential calculus and analyzing the predictive relationships between the factors derived from the questionnaire. A non-experimental cross-sectional design was implemented, using a structured questionnaire whose data were subjected to exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), complemented with multiple linear regression and tests of mean differences.

Participants

The sample consisted of 70 engineering students enrolled in a differential calculus course at an Ecuadorian university during the March-August 2025 academic period. Participants were selected through convenience sampling, which may limit the generalizability of the findings.

The training process was conducted by three teachers with different roles:

- (1) a teacher responsible for the theoretical classes,
- (2) a reinforcement teacher in charge of solving exercises with the MATLAB application, and
- (3) a practices teacher with academic support functions.

This structure made it possible to articulate theoretical, procedural and support components in the modality analyzed.

Instrument

A Likert-type questionnaire composed of 20 items was designed, with a four-point response scale (1 = strongly disagree; 4 = strongly agree). The items were developed from previous findings on innovative educational experiences (Brashi, 2022; Eccles & Wigfield, 2002; Emiru & Gedifew, 2024; Klassen & Klassen, 2018; Meng & Zhang, 2023; Schel & Drechsel, 2025). The aim of the instrument was to collect student perceptions of organizational, didactic and personal aspects of the learning process.

The questionnaire underwent content validation by a panel of experts in mathematics education and psychometrics, who assessed the relevance, clarity and appropriateness of the items. It should be noted that at this stage no prior dimensions were established, but rather the EFA sought to identify latent structures.

Procedure

The educational intervention was developed over eight weeks, with a load of 8 hours per week, distributed as follows: 4 hours of theoretical classes given by the main teacher, 2 hours of reinforcement sessions with MATLAB support and 2 hours of academic practices aimed at individual and group accompaniment. This distribution constituted the new proposed modality, which sought to integrate the conceptual, procedural and applied aspects of learning differential calculus.

The experience was implemented in four academic parallels: two corresponding to the software engineering degree, one to robotics and artificial intelligence engineering and one to digital transformation engineering. In order to optimize teaching resources and promote interaction between students, the theoretical classes were unified into two groups. In the first group, the two parallel sessions of software engineering were integrated, while in the second group, the robotics and artificial intelligence parallel sessions were unified with the digital transformation parallel session. In this way, the theoretical sessions were taught to larger groups, while the hours of reinforcement with MATLAB and the academic practices were maintained in the original parallels, allowing for more personalized work.

The content plan was structured in three thematic blocks that guided the development of the course. Block 1 dealt with the calculation of limits in functions of real variables, including functions and graphs, graphical and numerical calculation of limits, continuity, lateral and infinite limits. Block 2 focused on the derivative and its rules, including the derivative and the tangent line, the basic rules of derivation, the product and quotient rules, as well as higher order derivatives and implicit derivation. Finally, block 3 was oriented towards the optimization and applications of the derivative, covering intervals and extrema, Rolle's theorem, the mean value theorem, growth and decay criteria, concavity and convexity, and applications to maxima and

minima. At the end of the academic period, the questionnaire was administered anonymously and voluntarily using Google Forms, lasting approximately 20 minutes.

Data Analysis

Statistical analysis was performed using Python and R. First, the adequacy of the factor analysis was assessed using the Kaiser-Meyer-Olkin index (KMO) and Bartlett's test of sphericity. Then, an EFA with Varimax rotation was applied to identify latent dimensions, followed by a CFA with the WLSMV estimator, suitable for ordinal scales. Subsequently, a multiple linear regression model was constructed to assess the predictive ability of the identified factors. Finally, comparisons of means between factors were performed using Student's t-tests for related samples to identify significant differences in student ratings.

RESULTS

The findings obtained from the statistical analysis of the questionnaire and student responses are presented below. The results are structured according to the objective of the study and answer the research questions.

Validity of the Instrument and Factorial Structure of the Questionnaire

In order to verify the structural validity of the questionnaire designed to assess the students' perception of the alternative mode in the teaching of differential calculus, a psychometric analysis was implemented which integrated sample adequacy tests, EFA, CFA and conceptual refinement of the resulting factors.

In a preliminary phase, the relevance of the factor analysis was supported by a KMO index of 0.778, reflecting an acceptable to good fit, and by Bartlett's test of sphericity ($\chi^2 = 672.89$; $p < 0.001$), which confirmed the existence of sufficient correlations between the items. These results supported the application of factorial techniques to the instrument.

The PFA with Varimax rotation revealed a consistent four-factor structure. The first, modality and teaching experience, covers perceptions of the organization and coordination of the model implemented, and includes: The help of the teaching technician in small groups is useful (item 2), I prefer the current modality to the previous one (item 4), the remedial teacher fulfils his/her role effectively (item 5), there is coordination between the different teaching actors (item 9), the assessment methodology is clear (item 14), and this modality encourages collaborative work (item 18). The second factor, practices and resources, includes elements related to the experience in practical sessions, availability of materials and learning conditions, including: the practical teacher offers personalized attention (item 3), I actively participate in the practical sessions (item 11), the time allocated to the practical sessions is sufficient (item 12), the learning environment in the practical sessions is adequate (item 13), and the materials and resources provided are useful (item 17). The third factor, theoretical classes and demands, concentrates assessments on the quality and academic rigor of the course, with items such as theoretical classes are of good quality (item 1), they are sufficient to understand the concepts (item 8), I have had opportunities to clarify doubts with the teacher (item 15), and the level of demand is adequate (item 16). Finally, the fourth factor, self-efficacy and performance, integrates perceptions of personal performance, motivation and study habits, with the items: with the new modality I have reached a higher level of understanding (item 6), I would recommend implementing it in other courses (item 7), I expect to get better grades compared to the previous modality (item 10), this modality has increased my motivation (item 19), and I have developed better study habits (item 20).

Factor loadings were above 0.40 (Hair et al., 2010) and no problematic items were identified, allowing the instrument to be retained in its entirety. The AFC, estimated using WLSMV, confirmed the validity of the four-dimensional model, reaching convergence in 12 iterations and outstanding fit values (RMSEA = 0.042, CFI = 0.973, TLI = 0.968). All loadings were significant (0.68-0.84; $p < 0.001$), with item 1 ("theoretical classes are of good quality", $\lambda = 0.82$) standing out. Standard errors were in low ranges (0.03-0.06).

Standardized residuals remained within the expected threshold (± 1.96 in 93% of cases) and inter-factor correlations ranged between 0.18 and 0.65, confirming a differentiated but related structure. Overall, the results consolidate the internal validity of the questionnaire and support its usefulness for evaluating alternative educational experiences in engineering education.

Predictive Relationships Between Model Factors

In order to identify the interrelationships between the four factors derived from the EFA in differential calculus students in an alternative educational modality, a multiple linear regression model was developed in which each factor was alternately considered as a dependent variable, while the remaining three were incorporated as predictors. This strategy made it possible to examine cross-relationships and to determine the relative weight of each factor in explaining the others.

The results indicated that the self-efficacy and academic performance factor presented a robust prediction model, with a coefficient of determination of 72% ($R^2 = 0.72$; $F = 18.34$; $p < 0.001$). In this case, perception of teaching modality and experience ($\beta = 0.611$; $p < 0.001$) and practices and resources ($\beta = 0.298$; $p = 0.047$) were significant predictors. This finding suggests that students who perceive clear teaching, accompanied by relevant resources, develop greater confidence in their abilities and perform better academically.

As for the teaching modality and experience factor, it was observed that it was mainly explained by the dimension of theoretical classes and demandingness ($\beta = 0.455$; $p = 0.021$), with a secondary but consistent contribution from self-efficacy ($\beta = 0.238$; $p = 0.084$). This shows that students value the teacher's experience to the extent that the classes present an adequate level of organization and challenge, which increases the perception of pedagogical competence.

The practices and resources factor was significantly influenced by self-efficacy and academic performance ($\beta = 0.503$; $p = 0.004$). This relationship suggests that students with greater confidence in their abilities tend to be more actively involved in the use of resources and practical activities, which in turn enhances the appropriation of the content.

Finally, the factor of theoretical classes and demandingness showed a lower predictive power ($R^2 = 0.28$), although a moderate association with practices and resources was identified ($\beta = 0.312$; $p = 0.067$). Although the statistical significance was marginal, this result could be interpreted as an indirect effect, whereby the availability and quality of resources influence how students value theory classes.

Comparative Analysis of Student Rating by Factors

The analysis of the percentage distribution of student ratings by factors allowed us to identify differentiated trends in the participants' perception of the alternative mode of teaching differential calculus. In each case, three levels of assessment were considered: high (very satisfied/high), moderate (satisfied/moderate) and low (dissatisfied/low).

Figure 1 shows the results, firstly, factor 1, valuing the teaching modality and experience, shows a clear predominance of high valuation ($\approx 80\%$), followed by 15% at moderate level and only 5% at low level. This finding reflects a broad acceptance of the structure of the blended mode, the teaching coordination and the quality of the learning environment. Consistency with the results of previous surveys, which reported high levels of satisfaction with the educational intervention model (theoretical teacher, reinforcement and practices), confirms that the perceived weaknesses are minimal and do not substantially affect the overall student experience.

Secondly, factor 2, practices and resources, presents a more heterogeneous pattern, with approximately 55% high, 30% moderate and 15% low. This dispersion reveals tensions around active student participation, practice times and accessibility of resources. Although more than half of the students rate this component positively, the close to half with less favorable perceptions suggest that there are still challenges linked to equity of access, adaptation to different learning paces and the provision of supplementary materials.

Factor 3, theoretical classes and level of demand, was rated 65% high, 25% moderate and 10% low. Although the theoretical lectures were rated as clear and structured, a group of students stated that they were not sufficient for sustained autonomous learning. In addition, the level perceived as high by some participants seems to play a role in the moderate and low ratings. These results reinforce the need to incorporate additional reinforcement resources and greater clarity in the assessment processes, in order to favor the appropriation of theoretical content and reduce possible academic barriers.

Finally, factor 4, self-efficacy and performance, shows a significant predominance of high assessment ($\approx 75\%$), accompanied by 20% at a moderate level and 5% at a low level. This suggests that the majority of students

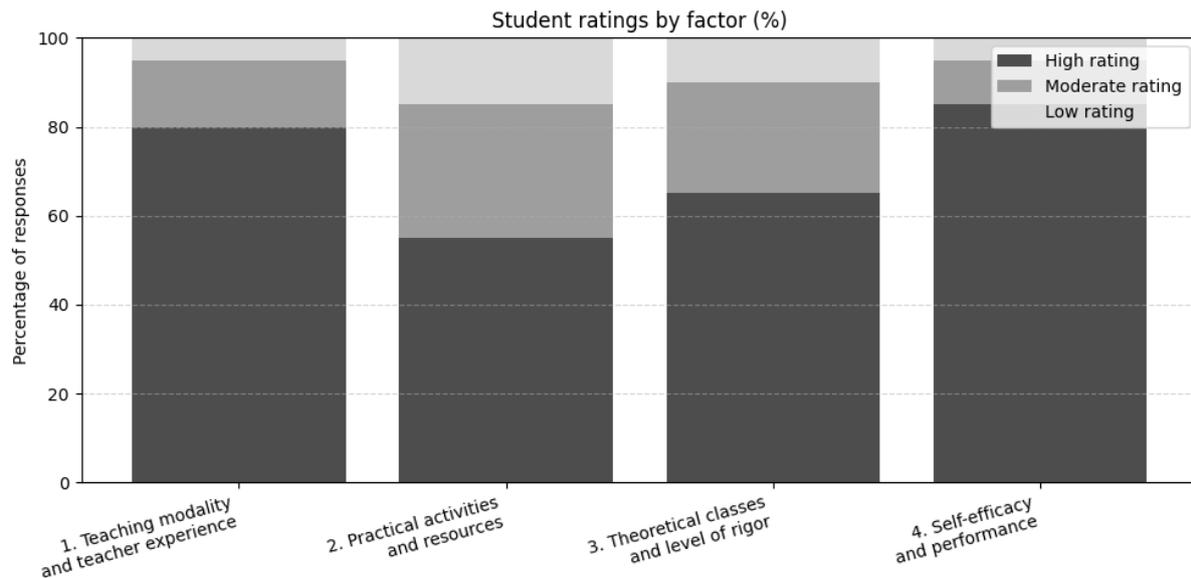


Figure 1. Percentage distribution of student ratings by factors of the education intervention (Source: Authors)

Table 1. Cross-matrix of *p-values* between factors

	F1. Modality	F2. Practices	F3. Theoretical classes	F4. Self-efficacy
F1. Modality	-	0.012	0.153	0.003
F2. Practices	0.012	-	0.145	< 0.001
F3. Theoretical classes	0.153	0.145	-	0.015
F4. Self-efficacy	0.003	< 0.001	0.015	-

perceived improvements in their motivation, study habits and confidence to face the course, which evidences the contribution of the modality to the consolidation of academic self-efficacy. However, the low percentage of low scores warns of the need to strengthen accompaniment strategies to attend to those who did not manage to fully benefit from the proposal.

Comparison of Mean Scores Between Factors Using Student's t-Test

In order to identify significant differences in student perception with respect to the different factors assessed in the questionnaire, t-tests for related samples were applied. This statistical technique is relevant since all factors were rated by the same participants, which implies dependence between observations. The analysis makes it possible to determine whether there are factors that stand out significantly above or below others in terms of their mean score, thus providing relevant information on the strongest or most problematic aspects of the educational modality analyzed.

Table 1 shows that factor 4 (self-efficacy and academic performance) is significantly different from the rest of the factors, with *p-values* less than 0.05 in all comparisons. This finding reflects that students give a significantly higher value to the self-efficacy dimension, indicating a strong sense of competence, motivation and personal control over one's own learning within the modality analyzed.

On the other hand, factor 1 (teaching modality and experience) also scores high, although significant differences were only observed in the comparison with practices and resources ($p = 0.012$) and with self-efficacy ($p = 0.003$), while the comparison with theoretical classes and demand did not show statistical significance ($p = 0.153$). This suggests that student perceptions of the teaching modality and experience are at an intermediate level: more favorable than those of practical's and resources, but with no clear differences with respect to the quality of the theoretical classes.

Finally, the comparisons between practices and resources and theoretical classes and demand were not significant ($p > 0.10$), indicating that both logistical and methodological components are rated similarly by students.

DISCUSSION

The findings of this study provide empirical evidence on the structure and dynamics of student perceptions of an alternative educational modality for teaching differential calculus. The validity of the instrument was confirmed by EFA and CFA, identifying four conceptually coherent factors that integrate organizational (modality and teaching experience), methodological (practices and resources; theoretical classes and demand) and affective (self-efficacy and academic performance) dimensions. This multidimensional structure is consistent with previous research highlighting the central role of teacher support, methodological clarity and self-efficacy in mathematics achievement (Bressoud, 2015; Usher & Pajares, 2009; Zakariya & Adegoke, 2024). Given the cross-sectional nature of the study, the relationships identified should be interpreted as associative rather than causal.

The fit indices of the confirmatory model support the relevance of the proposed factor structure, showing that student perception can be robustly represented through these four dimensions. The convergence of contextual, pedagogical and intrapersonal variables in the same model reinforces the holistic view of university learning in hybrid environments (Bressoud et al., 2015; Lazar et al., 2020).

At the predictive level, multiple regression analyses revealed that the factor self-efficacy and academic performance plays a central role: not only did it present the strongest explanatory model, but it also emerged as a significant predictor of the other factors, articulating the teaching and methodological perception with the subjective disposition to learning. This centrality coincides with self-efficacy theory (Bandura, 1997) and self-determination theory (Deci & Ryan, 2013), which stress the importance of competence and control beliefs in academic motivation and persistence (Pintrich, 2004; Zimmerman, 2010).

The analysis of the distribution by levels of appraisal complements this picture. While the factors modality and teaching experience and self-efficacy and performance were perceived more positively, the factors practices and resources and theoretical classes and demand showed more diverse opinions, including medium and low ratings in a considerable group of students. This finding indicates that, although the overall methodological design is well received, there are still tensions linked to the adequacy of resources, practice time and clarity of assessment, aspects that require adjustment to ensure fairness and effectiveness in the learning experience (Chechan et al., 2023).

The comparison between factors reinforced the privileged position of self-efficacy, which obtained significantly higher ratings than the others. Similarly, teaching modality and teaching experience achieved an intermediate perception: more positive than practices and resources, but with no clear differences with respect to theoretical classes. These results suggest a mediating effect of self-efficacy, whereby perceived quality of teaching and resources impacts motivation and academic performance (Bong & Skaalvik, 2003; Watkins, 2018).

Overall, the consistency of factor 4 (self-efficacy and achievement) not only as a predictor, but also as the highest rated component, underlines the need to design pedagogical strategies aimed at strengthening student confidence. Interventions such as personalized tutoring, continuous feedback and active methodologies focused on metacognitive skills can be decisive, especially in highly complex subjects such as differential calculus (Geng & Su, 2025; Usher & Pajares, 2009).

CONCLUSIONS

The questionnaire designed to assess student perception of the alternative modality in differential calculus demonstrated a sound psychometric validity, confirmed by EFA and CFA, which allows us to consider it as a reliable tool for future research in the field of university mathematics education. The factor structure identified revealed four differentiated and conceptually coherent dimensions, teaching modality and experience, practices and resources, theoretical classes and level of demand, and self-efficacy and performance, which integrate organizational, methodological and affective aspects of the teaching-learning process.

Among these, self-efficacy and academic performance emerged as the most relevant factor, not only because of its predictive power over the other factors, but also because it is the component with the highest

student assessment. This shows that confidence in one's own abilities and motivation are central to the educational experience, confirming that students who perceive methodological clarity and adequate support develop greater commitment and improve their academic performance.

On the other hand, although the teaching modality and experience was generally well rated, the factors related to practices and resources and theory classes presented more heterogeneous perceptions, which highlighted the need for adjustments in time management, the provision of complementary materials and the clarity of assessment processes. These tensions suggest that, in order to guarantee the equity and effectiveness of the model, it is necessary to strengthen the practice spaces and extend academic accompaniment.

Taken together, the results suggest that strengthening self-efficacy through personalized tutoring, constant feedback and active methodologies focused on the development of metacognitive skills can enhance student motivation and performance.

Limitations of the Study

This study has certain limitations that should be considered when interpreting its results. First, the sample size was moderate, which, while allowing for the required factor and statistical analyses, may limit the generalizability of the findings to other student populations or different academic programs. Secondly, the methodological design was cross-sectional, so data were collected at a single point in time during the learning process, which prevents us from establishing causal relationships or analyzing how motivation and perceptions evolve over time.

Areas For Future Research

Based on the findings and limitations identified, two lines of future research are proposed that would enrich and deepen the analysis carried out. First, it would be relevant to explore the role of moderating variables such as gender, career, or previous experience with educational technologies (e.g., MATLAB), in order to identify significant differences in the way students perceive and respond to alternative educational modalities. Secondly, it is recommended to complement quantitative studies with qualitative approaches, such as interviews or focus groups, which allow for a deeper understanding of students' perceptions, emotions and motivations, especially around the role of the educational technician and the effectiveness of the practices.

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Data availability: Data generated or analyzed during this study are available from the authors on request.

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