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Academic motivation and affective engagement toward science and math: the mediating role of self-efficacy

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The relationship between career choice and academic achievement associated with science, technology, engineering, and mathematics (STEM) fields has been extensively studied from the Educational Psychology Approach. The present study examined the impact of academic motivation on affective engagement, focusing on the mediating role of self-efficacy in pre-college students. A sample of 324 students between 17 and 19 years ($M = 17.41$; $SD = 0.506$; 51% females, 49% males) from different schools located in northwestern Mexico participated in completing a self-report questionnaire about math and science engagement, self-efficacy to science and math, and academic motivation. Statistical analyses were carried out to determine the reliability and validity of the measurement scale; posteriorly, a mediation analysis was used to determinate the direct and indirect effects of the structural model. The results revealed high correlations between the three study variables. Both mediation analysis and structural equation modeling indicated that academic motivation influences affective engagement through its relationship with self-efficacy. Although self-efficacy has a direct effect on affective engagement, it is also affected by academic motivation, so the interaction between these two generates an influence on affective engagement. In this research, a strong relationship was observed between academic motivation and self-efficacy, indicating that students who are motivated and enjoy performing activities related to their science and math classes have previous experiences of success in these tasks. These results provide new insights for the improvement of strategies regarding the training and performance of pre-university students in the areas of science and mathematics by considering their affective states.

KEYWORDS

STEM education, self-efficacy, academic motivation, affective engagement, science and math, pre-college students, educational psychology

1 Introduction

Scientific knowledge, research and technological development are important elements for the development of education and society ([Organisation for Economic Co-operation and Development OECD](https://www.oecd.org/), 2018). Therefore, promoting and disseminating the vocation and engagement to science in educational and social contexts is a strategy that could lead to an increase of university enrollment in undergraduate or engineering degrees related to Science,

Technology, Engineering and Mathematics (STEM). In addition, training in science allows the development of specific skills for decision making, critical thinking, and scientific reasoning, which according to [Madjar et al. \(2017\)](#) can be translated into competencies for life.

Understanding the causality of the events surrounding human beings allows the elaboration of explanations and rules of how various events operate and provides the opportunity to intervene at certain moments of the processes. [Bunge \(2017\)](#) mentioned that scientific experimentation allows us to predict consequences and make changes. Hence, the training of students within the field where scientific and technological innovation is produced can reinforce critical thinking and offer contributions for the solution of future conflicts in society.

In the Mexican context, during the last few years, new guidelines and training in science have been implemented to strengthen the scientific community due to the lag in the production of new knowledge and the lack of engagement of new generations ([National Council of Humanities, Sciences and Technologies - CONAHCYT, 2023](#)). Moreover, public policies have presented changes in the implementation of new strategies that promote the development of positive skills toward Science and Mathematics for the formation of responsible and informed decisions, the reflection of scientific knowledge, and how this can help to improve people's life condition in the future ([Orendain, 2019](#)). This lack of engagement in scientific and mathematics is justified by the results in the latest international evaluations of basic education levels, such as the Program for International Student Assessment (PISA). The 2018 application yielded an average below the one established by the Organization for Economic Cooperation and Development (OECD) ($x=490$) in the mastery of science and mathematics skills in basic education students.

In university education, the National Association of Universities and Higher Education Institutions ([ANUIES, 2020](#)) presented in the 2020 report the admission, completion, and graduation rates, which reflect a low enrollment in STEM-related careers. In regard to the graduation rates, from the 100% of students enrolled, only 17% finished their studies, and 13% managed to obtain a university degree. In the case of the productive sector, the [National Institute of Statistics and Geography INEGI \(2020\)](#) mentioned that these types of careers have a high labor supply due to the low demand they present, but why have these issues related to the disciplines of science and mathematics arisen? Studies developed in the Mexican context [i.e., ([Romero Bojórquez et al., 2014](#))] have identified that negative emotional factors play a significant role in the learning of mathematics and science. In particular, frustration and anxiety occur frequently among high school students when facing activities related to science and mathematics affecting their performance and attitude toward these subjects. In addition, [García-Santillán et al. \(2016\)](#) indicated that problem solving in science and mathematics classes can trigger or encourage negative emotions in students and could influence their establishment of professional goals and their academic motivation. Likewise, exploratory studies have found that the presence of positive self-efficacy beliefs in the school context are related to cognitive and affective variables in adolescents ([Ozkal, 2019](#)).

In such manner, the study of academic motivation and self-efficacy beliefs in science and mathematics is important because they are considered predictors for student engagement ([Azila-Gbetteor et al., 2021](#); [Mellado Jiménez et al., 2014](#); [Hampden-Thompson and Bennett, 2011](#); [Singh and Abdullah, 2020](#); [Froiland and Worrell, 2016](#)).

2 Theoretical background

In the field of psychology and education, there has been discussion regarding the factors that determine career choices, academic learning outcomes, and student achievement expectations in the context of undergraduate education ([Eccles and Wigfield, 2020](#); [Pedrero and Manzi, 2020](#)). Engagement, motivation, and self-efficacy are some of the psychological constructs most frequently found in studies related to academic achievement and career choice orientation in science ([Cerinsek et al., 2012](#); [Holmes et al., 2018](#); [Lichtenberger and George-Jackson, 2012](#); [Stankov and Lee, 2014](#)).

Thus, [Eccles and Wigfield \(2020\)](#) in the situated expectancy-value model established the importance of a cognitive component related to success expectations and value attributable to different academic and/or professional options available to everyone. Their analysis focused on the competencies and beliefs that in turn can be influenced by cultural norms and positive experiences ([Eccles et al., 1998](#); [Wang and Degol, 2014](#)). In such a manner, the situated expectancy-value theory is a broad framework that allows exploring factors considered by students to dedicate themselves to the STEM area ([Eccles and Wigfield, 2020](#); [Meece et al., 1982](#); [Simpkins et al., 2015](#)).

In addition, directing professional life toward STEM-related fields involves a process of reasoning and psychological factors in students. This decision-making process is often influenced by internal factors such as the degree of engagement, which is referred to as the observable and unobservable qualities of interactions with learning activities and students' choice processes ([Deci and Ryan, 1985](#); [Wang et al., 2016](#)).

2.1 Affective engagement

In the school context, engagement refers to students' participation in their education, as well as the relationships developed with other people and goals ([Pedrero and Manzi, 2020](#); [Skinner et al., 2009](#)). Some studies have referred to student engagement toward academic areas of science and mathematics as part of attitudes toward these subjects, the degree of participation, practical and theoretical training in STEM areas, student self-efficacy, and social perception toward these professions ([Lupi3n et al., 2019](#); [Williams et al., 2021](#)). Also, this construct has been addressed as an important factor in the process of vocational choice related to university careers in the field of science and mathematics ([Dopico and Armstrong, 2017](#)), as well as studies that explain students' motivation to learn about science ([Oppermann et al., 2019](#)).

Similarly, according to [Fredricks \(2011\)](#), engagement is composed of three major dimensions: the first is behavioral, related to the performance of activities associated with the goal; followed by the cognitive dimension, related to self-regulation and understanding of topics or activities related to the goal; and finally, the affective component, where positive or negative emotions are manifested toward certain topics or even teachers ([Wang and Liou, 2018](#)). Engagement is considered fundamental to academic achievement in subjects such as science and mathematics ([Lee et al., 2019](#); [Wang and Degol, 2014](#)), because when a student is engaged, he or she is influenced by motivation and his or her beliefs about achieving the goals set in school. Emotions and feelings are an integral part of students when they experience learning situations, and this can

influence their engagement in certain academic activities when they experience positive emotions, interest, or negative emotions such as frustration or boredom (Attard et al., 2020; Reeve, 2012).

Studies have found that student engagement is related to excellent functioning and learning motivation (Fraysier et al., 2020). Additionally, this behavioral and affective engagement is modulated by the level of self-efficacy of students (Olivier et al., 2019).

2.2 Academic motivation

It has been studied that one of the main causes of behavior is the motives that lead people to perform them, since motivation affects the initiation, persistence, change, direction toward goals and termination of any behavior (Reeve, 2018). The sources of a person's motivation can be intrinsic, derived from internal processes associated with pleasure and enjoyment; or extrinsic, which comes from external forces involving behaviors aimed at meeting specific goals (Deci and Ryan, 1985; Staribratov and Babakova, 2019).

Within Educational Psychology, academic motivation is referred to as the disposition that is related to academic functioning, learning and success, as well as the effort made by students and persistence to achieve the goals, they set for themselves (Schunk, 2008). Research studies have shown how motivation is related with students' engagement (Schunk and Mullen, 2012). Other studies explain that motivational regulation is a positive predictor of satisfaction to learn and study STEM-related subjects and/or careers; also, studies found indirect effects with affective states, such as stress (Kryshko et al., 2022; Oppermann et al., 2019; Wang and Liou, 2018).

For the present study, greater emphasis is placed on intrinsic motivation for learning because of the relationship found with positive affective states and the development of positive attitudes toward science and mathematics in high school students (De Loof et al., 2019). Also, studies presented relationship between academic motivation with young people's perceived self-efficacy about their abilities in science and mathematics, which predicts likely what they are to choose and pursue STEM careers (Kiran et al., 2019; Fong-Silva et al., 2017; Silva et al., 2018; Sáinz et al., 2020). Moreover, the positive relationship between engagement and academic motivation (De Naeghel et al., 2012), and with academic achievement in science and mathematics (Singh et al., 2002).

2.3 Self-efficacy as a mediator between academic motivation and affective engagement

In school contexts and educational psychology, the term self-efficacy proposed by Albert Bandura (1997) has been used to explain how a belief or judgment that a person has toward him/herself about the skills he/she possesses influences the fulfillment of certain activities or goals (Wigfield et al., 2011; Wigfield and Eccles, 2023). In this context, self-efficacy is a belief that affects, on a regular basis in a positive way, students' academic achievement outcomes resulting in the choice of tasks that represent difficulty for them, greater planning of the strategies to be used and engagement toward certain learning situations (Zeldin et al., 2008; Usher et al., 2019; Zimmerman and Cleary, 2009). These

beliefs or judgments stem from sources such as previous experiences of success, peer comparison experiences, social persuasion, and emotional states (Bandura, 1997), which, along with motivation are considered determinants toward choosing STEM careers and engagement to staying in them (Rosenzweig and Wigfield, 2016). In the field of educational psychology, studies have shown that self-efficacy is associated with affective engagement and academic achievement (Olivier et al., 2019), as well as to learning performance in science and mathematics (Ozkal, 2019). Also, it plays a critical role in the self-regulation of motivation and engagement (Azila-Gbetteo et al., 2021; Close and Solberg, 2008).

On the other hand, self-efficacy in various studies has been determined as a mediating variable for career choice (Agoes Salim et al., 2023; Hackett and Betz, 1995; Restubog et al., 2010; Song and Chon, 2012; Liu et al., 2023), and to explain learning and school performance associated with parental support (Cattellino et al., 2019). Others have taken up such variable to assess the effects of perceived task-goal structure, perceived ability structure, and academic performance (Høigaard et al., 2015), task appraisal and learning and achievement in mathematics and science (Gao et al., 2020; Yurt, 2022), as well as appraisal of learning environments and academic engagement (Sökmen, 2021). This construct has also been used to explain and predict good performance in science and mathematics, such as the likelihood of choosing a career in the STEM field (Van Aalderen-Smeets et al., 2019; Jansen et al., 2015; Kulakow, 2020).

The aforementioned studies take up this construct as a mediating variable. In statistical terms, mediation refers to a causal link, where it is assumed that the effect of one or more independent variables is transmitted to other dependent variables through a third variable, and this link indicates the effect between these variables (Baron and Kenny, 1986; MacKinnon et al., 2007). Mediation can occur in three different types: complementary mediation, where direct and indirect effects are significant and point in the same direction; competitive mediation, where direct and indirect effects are significant, but go in opposite directions; and indirect mediation, where indirect effects are significant, but the direct effect is not (Hayes, 2013; Hair et al., 2017).

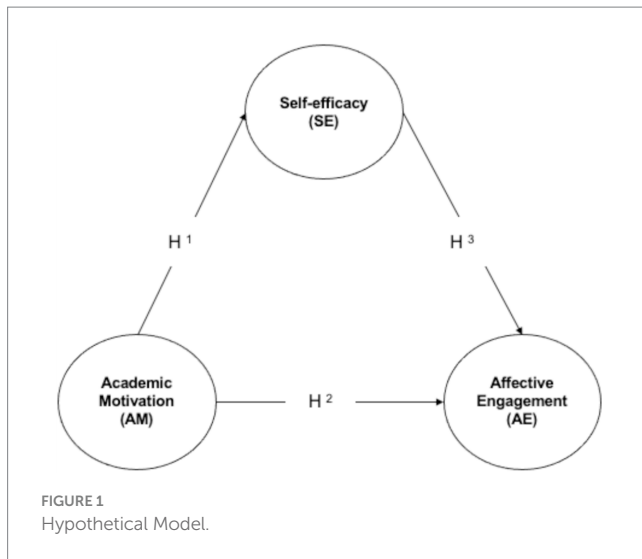
2.4 The present study

Given that, in educational y psychological research, emphasis is placed on motivation, self-efficacy beliefs, and engagement as important constructs for goal achievement and career choice in STEM-related subjects. It was decided to investigate the relationship between these three variables. In addition, since self-efficacy may play a role as a mediating variable for the relationship of academic motivation and affective engagement, the assessment of this mediation was determined. It was also tested how self-efficacy affects this relationship. In Figure 1, we hypothesize that:

H1: Academic Motivation would be positively related to Affective Engagement.

H2: Academic Motivation would be positively related to Self-Efficacy.

H3: Self-efficacy would be positively related to Affective Engagement.



3 Methods

3.1 Sample

The sample was delimited using the non-probability method by quotas, since the selection of participants did not depend on probability but on causes related to the characteristics of the research (Hernández, et al., 2014). A total of 324 high school senior students from the city of Hermosillo, Mexico participated, belonging to four schools: three from the private sector (47.5%) and one from the public sector (52.5%). The sample consisted of 49% male and 51% female students aged between 17 and 19 years old ($M=17.41$, $SD=0.506$).

3.2 Measurement

Math and Science Engagement Scale: Participants used a 10-item scale modified from Wang et al. (2016), which measures the degree of emotional co-engagement that high school students have toward science and math related classes and activities. Each item was measured with a 5-point Likert scale (1 = agree, 5 = disagree). The items included situations such as “I think that math/science class is not boring,” “I care about learning science/math” and “I often feel good when I am in science/math class.”

Self-efficacy Scale: We developed a scale to assess students’ perceptions of self-efficacy in relation to their previous success experiences during science and mathematics classes, as well as their emotional states in these subjects (Bandura, 1997). The 12-item scale was measured on a 5-point Likert scale (1 = Never, 5 = Always).

Academic Motivation Scale: A motivation scale for science and mathematics was adapted from the Academic Motivation Scale instrument (AMS-Mathematics: Staribratov and Babakova, 2019). The scale consisted of 11 items divided into two factors: intrinsic motivation and extrinsic motivation. The response options ranged from 1 (strongly disagree) to 5 (strongly agree).

3.3 Procedure

After the approval of the Research Ethics Committee of the University of Sonora (CEI-UNISON), we contacted the high schools’ principals with the highest enrollment in the city to request permission to apply the surveys to senior students. Once granted, we approached the classrooms and explained the purpose of the study. Participation was completely voluntary and anonymous, and participants were invited to sign a statement of informed consent. It took an average of 25 min to complete the questionnaires. Data was collected in May 2022, and the participation rate was approximately 78.07%.

3.4 Statistical analysis

The data was captured and analyzed using the Statistical Package for the Social Sciences (SPSS v25.0) to obtain the psychometric properties of each of the scales. Univariate descriptive statistics were calculated for each of the items, as well as the internal consistency through Cronbach’s alpha, and the correlations between each of the variables.

To test the hypotheses, a series of statistical analyses were performed in the framework of Structural Equation Modeling (SEM). First, structure was obtained through Confirmatory Factor Analysis (CFA) for each of the variables; after that, SEM was tested in EQS Software 6.1. The indices used for estimating the goodness of fit of the models were chi-square hypothesis test (χ^2), normed fit index (NFI), non-normed fit index (NNFI), comparative fit index (CFI) and the root mean square error of approximation (RMSEA), (Hu and Bentler, 1999). Models were considered to have a good fit if all coefficients were marked as significant at the 0.05 level, goodness-of-fit indices scored above 0.95, and RMSEA remained below 0.08 (Bentler and Bonett, 1980; Bentler, 1990; Kline, 2016).

In addition, beta coefficients and mediation confidence intervals were calculated using SPSS v25.0 with the Process add-on (Hayes, 2013) allowing to establish the dependence relationship between two or more variables and the values of a third variable as mediator in the model. To test the role of mediation and its effects, the bootstrapping method was used which involves repeated sampling of the data set and estimates the indirect effect and confidence intervals (CI) for the mediation effect. A 95% CI with 5,000 iterations was used allowing us to find more precise intervals and determine the significance of the effects, with the aim of accepting the raised hypotheses (Hayes, 2013; Hair et al., 2017).

4 Results

4.1 Descriptive statistics and correlation analysis

Table 1 presents the variables correlation matrix and their internal consistency. Cronbach’s alpha values of the different scales used in the study were appropriate ($\alpha > 0.6$) indicating adequate consistency in each one. As for the correlations, it was found that self-efficacy has a positive and highly significant correlation with academic motivation ($r=0.767^{**}$), followed by the relationship between affective engagement and self-efficacy ($r=0.621^{**}$). These observations lead us to question if the scales for self-efficacy and academic motivation measure very similar concepts or refers to a conditional effect. Therefore, the existence of

TABLE 1 Univariate statistics and their relationship with academic motivation, self-efficacy, and affective engagement.

	Mean	σ	Alpha	AM	SE	AE
AM	3.5	0.91	0.86	1		
SE	3.2	1.03	0.90	0.767**	1	
AE	3.7	0.95	0.79	0.615**	0.621**	1

$N=324$; σ , standard deviation; AM, academic motivation; SE, self-efficacy; AE, affective engagement.

multicollinearity was verified through a regression analysis using variance inflation factors (VIF) and tolerance statistics (Berseley et al., 1980). Through the results, we can determine that there is no evidence of collinearity when entering self-efficacy alongside academic motivation (VIF = 1.000, Tolerance = 1.000). Additionally, in the linear regression analysis between the variables mentioned, Mahalanobis distance and Cook's distance and distance were assessed to identify influential and outlying observations. Mahalanobis distance reported a minimum value of 0.011, a maximum value of 8.021 ($M=0.997$, $S.D.=1.41$), indicating that while most observations are close to the multivariate mean, some are potentially outliers and could be significantly distant from the center of the distribution, warranting further examination to ensure the robustness of the model. In contrast, Cook's distance exhibited a minimum value of 0.00, a maximum value of 0.49 ($M=0.003$, $S.D.=0.006$), suggesting that most observations exert minimal influence on the estimation of regression coefficients, although one observation with 0.49 might have a relatively greater impact without exceeding the commonly concerning threshold of 1 (Cook and Weisberg, 1982).

Regarding the results of the regression analysis between affective engagement and self-efficacy, significant patterns emerge. The Mahalanobis distance exhibits moderate variability among observations, ranging from a minimum of 0.000 to a maximum of 4.18, indicating that some observations deviate notably from the centroid of the group. Univariate statistics suggest considerable dispersion around the mean ($M=0.997$; $S.D.=1.185$). Both VIF and tolerance values are 1.000, indicating no serious issues of multicollinearity. Additionally, the Cook's distance shows minimal changes due to outlier observations, with a maximum of 0.105 and a mean of 0.004.

In addition, the Durbin-Watson statistic was also considered to test autocorrelation, whose values were found to be $d=1.92$ for the relationship between self-efficacy and affective engagement; and $d=2.15$ for the relationship between self-efficacy and academic motivation.

4.2 Structural equation model

The confirmatory factor analysis (CFA) was performed using the robust maximum likelihood estimation method to estimate the goodness-of-fit indicators as well as the factor loadings for each of the indicators of the three latent variables of the study (Stommel et al., 1992). The test of the measurement models resulted in satisfactory fits to the data. In addition, all factor loadings on the latent variables were significant ($p < 0.05$) indicating that the latent constructs were well represented by their indicators.

In our structural model, the mediating role of self-efficacy was tested in relation to academic motivation and affective engagement (Figure 2). All paths were marked as significant. The goodness-of-fit indexes indicated an acceptable fit between the data and the structural

model ($\chi^2: 80.66$, 29 gL, $p < 0.05$; BBNFI = 0.96; BBNNFI = 0.96; CFI = 0.98; RMSEA = 0.07, explaining 77% of the total variance).

4.3 Direct and indirect effects

When examining the total effect of academic motivation on affective engagement, a statistically significant value was found [$\beta=0.648$, $p=0.00$, 95% CI (0.73; 0.61)]. Thus, the result indicates that academic motivation positively predicts affective engagement toward science and mathematics. As for the direct effect of academic motivation toward self-efficacy, positive and significant values were found [$\beta=0.601$, $p=0.00$, 95% CI (1.05; 1.27)] which represents a coefficient very similar to the total effect. The direct effect of self-efficacy on affective engagement also showed a positive and significant result, but with a lower coefficient [$\beta=0.362$, $p=0.00$, 95% CI (0.16, 0.34)].

When we examined the indirect effects (Table 2), it was found that the effect of the mediating variable self-efficacy on the relationship between academic motivation and affective engagement was a complementary mediation [$\beta=0.292$, $p=0.00$, 95% C (0.16; 0.42)]; since, despite presenting a smaller effect, it did not fail to be statistically significant (Baron and Kenny, 1986; Hayes, 2013).

The results indicated that academic motivation affects affective engagement through its relationship with self-efficacy. Although self-efficacy has a direct effect to affective engagement, it is also affected by academic motivation, so the interaction between these two generate an influence on affective engagement (AM*SE; $0.77*0.36$). The interaction gives the indirect effect value of 0.27 and allows to explain the correlation value of 0.61 between academic motivation and affective engagement. That is, to improve engagement it is necessary to affect the academic motivation and self-efficacy, since together generates an indirect effect on affective engagement.

5 Discussion

This study examined the relationship between academic motivation, self-efficacy, and affective engagement. In addition, the mediating role of self-efficacy between the relationship between academic motivation and affective engagement was analyzed. Prior to the implementation of the structural equation model, the constructs were previously validated by obtaining acceptable goodness-of-fit indexes according to the criteria established by Bentler and Bonett (1980) and Kline (2016). The tested model consisted of academic motivation as an independent variable, affective engagement as a dependent variable, and self-efficacy as a mediating variable. It was found that self-efficacy plays the role of complementary mediation in the relationship, as both its direct and indirect effects were significant (Hayes, 2013; Hair et al., 2017).

Firstly, it was found during the measurement models of each variable that students take into consideration their emotional states in their decisions about science and/or mathematics careers and their performance in such subjects during school. Academic motivation presented high factorial loads in the items related to enjoyment of related activities, which is consistent with the studies of Mai et al. (2023), Membiela et al. (2023), Wood (2019). As with the variable of engagement, the dimension of affective states was the only one able to explain engagement with science and mathematics in high school seniors, which is a similar result to other research areas of psychology

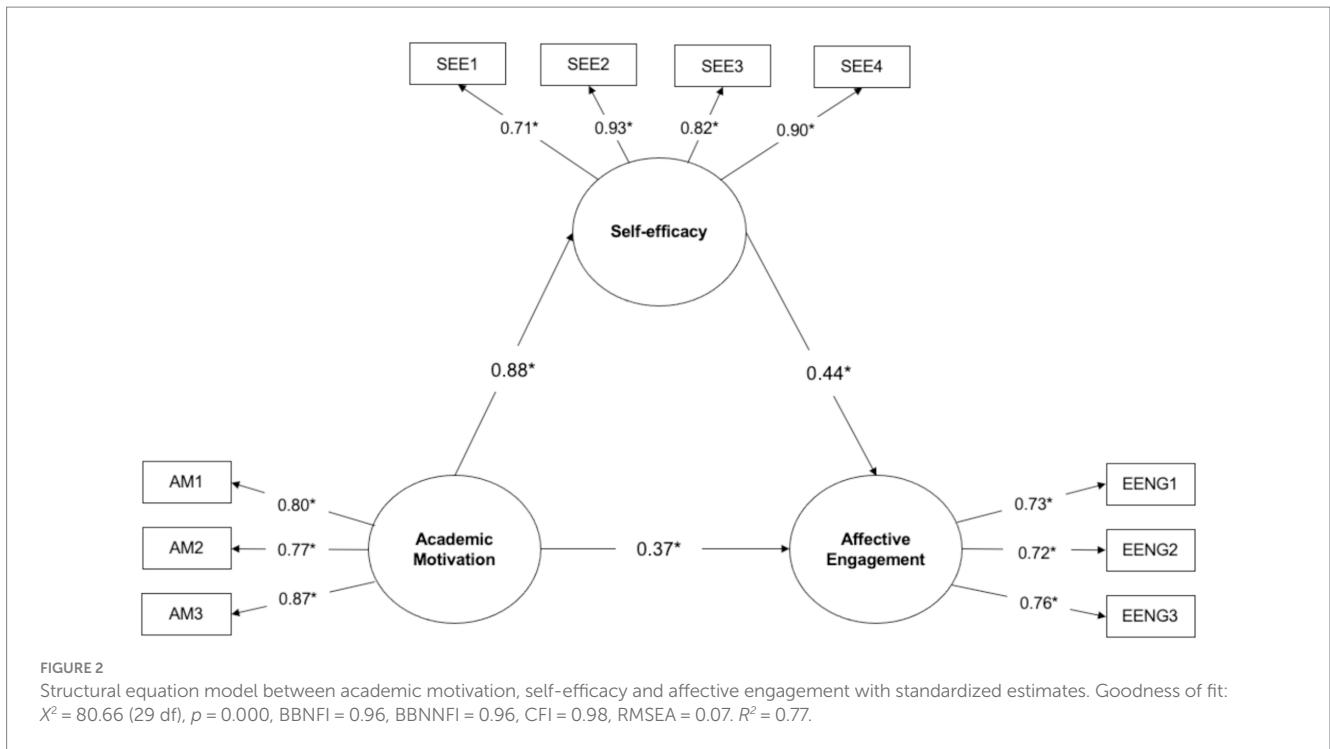


TABLE 2 Direct and indirect effects and 95% confidence intervals for the final model.

Model paths	β	σ	p	95% CI	
				Lower bonds	Up bonds
Total effect					
Academic Motivation → Affective Engagement	0.648	0.046	0.000	0.739	0.614
Direct effect					
Academic Motivation → self-efficacy	0.601	0.054	0.000	1.058	1.271
Self-efficacy → Affective Engagement	0.362	0.045	0.000	0.162	0.341
Indirect effect					
Academic Motivation → (self-efficacy) → Affective Engagement	0.292	0.067	0.000	0.165	0.427

σ , standard deviation; CI, confidence intervals at 95%; $p < 0.05$.

and STEM education (Jang et al., 2010; Murphy et al., 2019; Lee et al., 2019; Phillips et al., 2019).

As for the mediating variable of self-efficacy, there are numerous studies in the field of educational psychology that take up this psychological variable to explain how students' beliefs affect their

academic performance. In this research, a strong relationship was observed between academic motivation and self-efficacy, indicating that students who are motivated and enjoy performing activities related to their science and math classes have previous experiences of success in these tasks; in addition to experiencing positive affective states (Bellová et al., 2023; Ozkal, 2019; Kwon et al., 2023).

For the full structural model, we can conclude that these three psychological constructs help us to understand and explain motivation, beliefs about learning, fulfillment, and goal orientation of students at different educational levels. In high school students, who are close to making a career choice, it is considered important to address affective states, since are an important element that is not considered in educational settings, although they are an important factor for decision making and for the development of engagement toward science and mathematics (Iztek-Greulich and Vollmer, 2017). Likewise, self-efficacy was found to have an indirect effect in the existing relationship between academic motivation and affective engagement with science and mathematics among high school students, so that the development of engagement to STEM fields and activities depends not only on students' motivation, but also on their beliefs about their own scientific and mathematical abilities and their previous and enjoyable experiences (Jones et al., 2000).

5.1 Implications for educational psychology

Our findings serve to provide a new perspective on the approach to the development of vocations in science and mathematics, as well as to reinforce and justify the importance of the implementation of programs such as PAUTA, which is a strategy that promotes the development of scientific vocations and the reinforcement of skills in children and adolescents with outstanding interest and aptitude in

science and is responsible for accompanying them throughout their school career. This program also carries out the work of teacher training in science and links with the scientific community (PAUTA, 2013). The study also helps to confirm that the intervention of the psychologist in educational contexts is of utmost importance to identify the needs that students may have to achieve goals in science and/or mathematics, and thus provide the necessary strategies for both students and teachers to develop self-efficacy beliefs and thus motivate and engage students in learning various topics in STEM education and educational psychology.

5.2 Limitations

Our limitations are related to the size of the sample used for the study, in addition to the fact that the students were selected for the convenience of the research team, considering only that they were students about to graduate from high school. Therefore, the study is limited to a specific developmental environment due to the characteristics of the school environment where the data collection took place.

Several studies have also been conducted on the development of scientific vocation considering gender differences (Tzu-Ling, 2019; Ugwuanyi et al., 2020; Voica et al., 2020; Li and Singh, 2021; Fredricks et al., 2018; Tellhed et al., 2017; Liou et al., 2021), so for future research, in addition to expanding the sample, one could consider working on analyses that consider the demographic variable of gender and explore whether there are significant gender differences. Moreover, future research could explore the distinct measurement of science self-efficacy and mathematics self-efficacy among Mexican high school students. Although educational system typically integrates these subjects, understanding students' perception specific to each discipline could provide more nuanced insights.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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Ethics statement

The studies involving humans were approved by the Research Ethics Committee of the University of Sonora (CEI-UNISON). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

RV-P: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. CT-F: Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing. BF-S: Data curation, Methodology, Supervision, Writing – review & editing. JM-B: Data curation, Formal analysis, Methodology, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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