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MOTIVATION AND MATHEMATICS ACHIEVEMENT: A VIETNAMESE CASE STUDY

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Abstract

Motivation is key to engaging students in studying mathematics and in improving their mathematics achievement. Although the related literature has explored the correlation between motivation and mathematics achievement, a research gap remains in terms of the empirical testing of these variables in the context of mathematics education in Vietnam. Thus, the current study aims to fill this gap by empirically testing the correlation between mathematics motivation and mathematics achievement among high school graduate students in Vietnam, using a quantitative approach to test hypotheses. The study adopted the Academic Motivation Toward Mathematics Scale for collecting data from students and received 680 responses. The main study findings are that amotivation negatively correlates with mathematics achievement, whereas introjected regulation, identified regulation and intrinsic motivation positively correlate with mathematics achievement. These findings provide a strong theoretical foundation for improving mathematics achievement by encouraging teachers to improve motivational conditions in mathematics classes in Vietnam.

Keywords: Mathematics Motivation, Mathematics Achievement, Introjected Regulation, Identified Regulation, Intrinsic Motivation

Abstrak

Motivasi memiliki peran penting dalam melibatkan siswa untuk belajar matematika dan meningkatkan prestasi matematika mereka. Hubungan korelasi antara motivasi dan prestasi matematika telah dieksplorasi dalam penelitian sebelumnya; namun, terdapat kesenjangan penelitian pada hal uji empiris untuk elemen utama dalam konteks pendidikan matematika di Vietnam. Oleh karena itu, penelitian ini bertujuan untuk memecahkan masalah penelitian dengan menguji secara empiris korelasi antara motivasi matematika dan prestasi matematika di kalangan siswa lulusan sekolah menengah di Vietnam. Penelitian ini menggunakan pendekatan penelitian kuantitatif untuk menguji suatu teori. Penelitian ini mengadopsi tes *Academic Motivation Toward Mathematics Scale* (AMTMS) untuk mengumpulkan data. Enam ratus delapan puluh tanggapan diterima siswa sekolah menengah. Terdapat beberapa poin utama yang dihasilkan dari penelitian ini. Motivasi telah terbukti berkorelasi negatif dengan prestasi matematika. Namun, regulasi yang diintrojeksi, regulasi yang teridentifikasi dan motivasi intrinsik berkorelasi positif dengan prestasi matematika. Temuan yang dihasilkan pada penelitian ini memberikan landasan teoritis yang kuat untuk meningkatkan prestasi matematika dengan mendorong guru untuk meningkatkan kondisi motivasi di kelas matematika di Vietnam.

Kata kunci: Motivasi Matematika, Prestasi Matematika, Regulasi Introjeksi, Regulasi Teridentifikasi, Motivasi Intrinsik

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Mathematics education has attracted considerable attention from educators and scholars (Attard et al., 2016). The literature has shown that individuals' attitudes, beliefs and emotions play a vital role in their responses to, and interest in, mathematics, as well in their application of mathematics in real-word situations (OECD, 2018). In particular, enhancing the motivational conditions in their classroom for students is crucial for improving mathematics teaching and learning owing to its relationship with their behaviour and achievement (Pantziara & Philippou, 2015). Students who feel more confident about their mathematical skills are more likely than their less-confident counterparts to apply mathematics in different situations (OECD, 2018). Consequently, in mathematics education, developing students' attitudes, beliefs and emotions is a main objective. Aeschlimann et al. (2016) stated that enhancing motivational conditions in mathematics and science classes is a promising intervention strategy to ensure that more individuals participate in science, technology, engineering and mathematics occupations.

In this regard, motivation and engagement seem to be attracting increasing research attention in the mathematics education field (Attard et al., 2016). Motivation is among the most affective domains identified to strongly relate to mathematics achievement (Lim & Chapman, 2015b). The role of motivation in teaching and learning mathematics has been widely reported. Hannula (2006) revealed that motivation can be used for directing behaviour to control emotion and that individuals' motivation is revealed through three aspects: their cognition, behaviour and emotion. Pantziara and Philippou (2015) provided insight into motivation through these three aspects: Cognition occurs when people believe in the essence of a task. Behaviour occurs when they have a consistent strategy for solving problems. Emotion occurs when they feel disappointed on failing to address problems.

Moreover, students' perceptions about their classroom and school environment affect their motivation to study mathematics (Polychroni et al., 2012). The achievement goal theory has suggested that a likely characteristic that motivates students to learn mathematics is the classroom goal structure (Maehr & Zusho, 2009). A goal structure is defined as the way that achievement goals are designed through education policies and practices (Wolters, 2004; Skaalvik et al., 2017). It has two general forms: the mastery goal structure and the performance goal structure (Patrick et al., 2011; Skaalvik et al., 2017). The mastery goal structure focuses on developing competence, whereas the performance goal structure focuses on demonstrating competence (Patrick et al., 2011; Skaalvik et al., 2017). Skaalvik et al. (2017) emphasised that it is vital to identify the types of elements that affect students' motivation.

In Vietnam, mathematics is one of the most important subjects at school. It is one of three compulsory subjects in the National High School Graduation Examination. Parents usually encourage their children to study mathematics as they believe that it will assist in further studies. Further, people who are good at mathematics are often viewed as smart. Therefore, there are many interventional activities undertaken by both educators and parents that seek to improve mathematics education in Vietnam. Schools organise a formal class outside of the official school timetable to teach students. Parents often seek a private tutor for their children to foster mathematical achievement. These activities are criticised by society because they may place even more pressure on students. However, as suggested by Aeschlimann et al. (2016), one emerging intervention strategy to improve students' mathematics achievement is to improve the motivational conditions in the mathematics classroom. In addition, Lim and Chapman (2015b) discovered that motivation is one of the most affective domains that has strong correlation with mathematics achievement. Further, Aeschlimann et al. (2016) emphasised that the enhancement of motivational conditions in mathematics classes has emerged as an encouraging intervention strategy to improve mathematics achievement. Therefore, mathematics motivation can be a potential intervention strategy for improving mathematics achievement in Vietnam. Consequently, understanding the correlation between mathematics motivation and achievement in the Vietnamese context is vital for improving mathematics achievement. However, until date, no empirical study has focused on this issue. Therefore, this study aims to address this gap and to identify the related affective factors by answering the following research question: What is the correlation between mathematics motivation and mathematics achievement in Vietnam?

Mathematics Motivation

According to the self-determination theory, the three types of academic motivation are amotivation, extrinsic motivation and intrinsic motivation (Deci & Ryan, 1985). Figure 1 illustrates the self-determination continuum. Amotivation can be defined as people's lack of interest in performing a task because they do not perceive its value or feel unable or incompetent to achieve the expected results (Deci & Ryan, 2000). Intrinsic motivation can be defined as the internal demand to accomplish a task owing to the satisfaction it offers (Deci & Ryan, 2000). In contrast, extrinsic motivation—which is situated between the other two types on the continuum—includes external, introjected, identified and integrated regulation. As regards intrinsic motivation, it has been found to positively correlate with achievement (Ahmed et al., 2010; Woolley et al., 2010). Further, intrinsic motivation is associated with autonomous forms of extrinsic motivation and positive academic achievement (Deci et al., 1991; Grolnick et al., 1991).

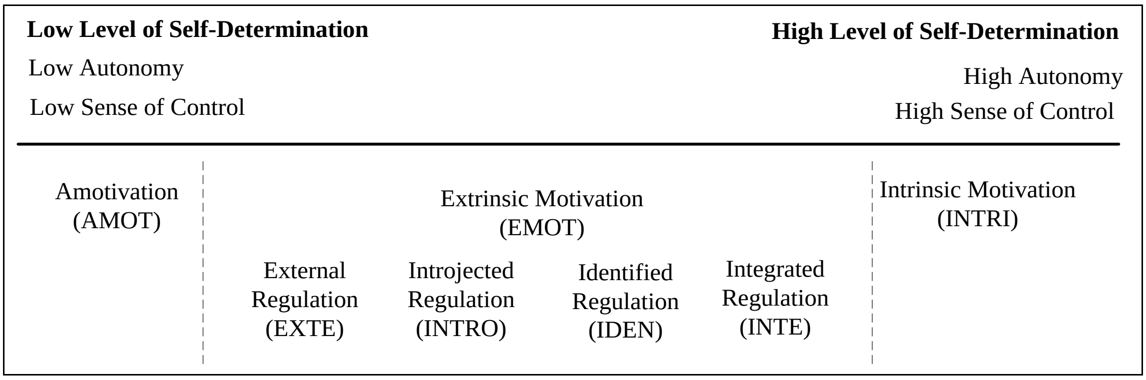

Figure 1. Self-determination continuum (adapted from Deci and Ryan (2000))

As regards the types of extrinsic motivation, the first, external regulation causes people to act to obtain a desirable outcome (Deci & Ryan, 2000). The second, introjection, can occur when individuals feels that they 'ought to' participate in an activity, and it is a more internal type of extrinsic motivation than external regulation (Wang et al., 2009; Lim & Chapman, 2015b). The third, identified regulation, is the most internal type of extrinsic motivation and occurs when people identify with the justifications for their actions (Lim & Chapman, 2015b).

Several studies have discovered the correlations between mathematics motivation and achievement. Mathematics motivation can be measured through intrinsic motivation, identification, introjection, external regulation and amotivation (Lim & Chapman, 2015a). Research has indicated that motivation positively correlates with the desired outcome, such as good academic performance (Gottfried et al., 2007). However, the lack of academic motivation negatively correlates with educational results (Barkoukis et al., 2008). Several highly negative outcomes are associated with amotivation (Deci & Ryan, 2000). Moreover, intrinsic motivation and amotivation were statistically associated with mathematics achievement (Lim & Chapman, 2015a). Amotivation was found to be negatively correlated with mathematics achievement among Years 11 and 12 mathematics students in Singapore (Lim & Chapman, 2015a). Herges et al. (2017) found that intrinsic motivation positively associates with mathematics achievement for middle school students in Years 6, 7 and 8. Further, mathematics achievement has a positive correlation with identification (Lim & Chapman, 2015a). However, Lim and Chapman (2015b) noted that future studies on students from different cultures and countries were warranted because their findings were based on a sample of Chinese students in Singapore.

In addition, studies have shown that students' motivation and performance are influenced by their learning environments, such as through the classroom goal structure, namely, the performance goal and mastery goal structures (Maehr & Zusho, 2009). A teacher who applies a mastery goal structure can emphasise students' effort, understanding and improvement and view mistakes as part of the learning environment (Patrick et al., 2011). The success of students is assessed based on their improvements and their ability to judge. In contrast, when using a performance goal structure, a teacher may promote comparison or competition among students and make public the achievement of all students, rather than emphasising effort and improvement (Patrick et al., 2011). Students' success in the performance goal structure is defined by surpassing targets or outperforming others (Patrick et al., 2011).

Thus, the discussion thus far reveals that through identifying effective elements in mathematics education, mathematics teachers may apply valuable intervention strategies for assisting students to improve their self-confidence in mathematics. This approach may result in improved mathematics performance. However, the correlation between mathematics motivation and achievement in Vietnam is yet to be empirically tested. Therefore, an empirical study on this correlation is necessary.

METHOD

Conceptual Model and Hypothesis Development

Figure 2 presents the current research model. The direct correlations of (1) amotivation, external regulation, introjected regulation, identified regulation and intrinsic motivation with (2) mathematics achievement are empirically tested. Obviously, one indicator of the self-determination continuum was not included in the indicators of motivation in the present study (i.e., integrated regulation). The main reason was that the current study adopted the Academic Motivation Toward Mathematics Scale (AMTMS) which was developed by Lim and Chapman (2015a) based on the Academic Motivation Scale (AMS) (Vallerand & Blssonnette, 1992). Please note that the AMS was developed based on the self-determination theory (Deci & Ryan, 1985) and it measures academic motivation in general, while the AMTMS measures academic motivation in mathematics. The AMTMS includes amotivation, external regulation, introjection, identification and intrinsic motivation to accomplish.

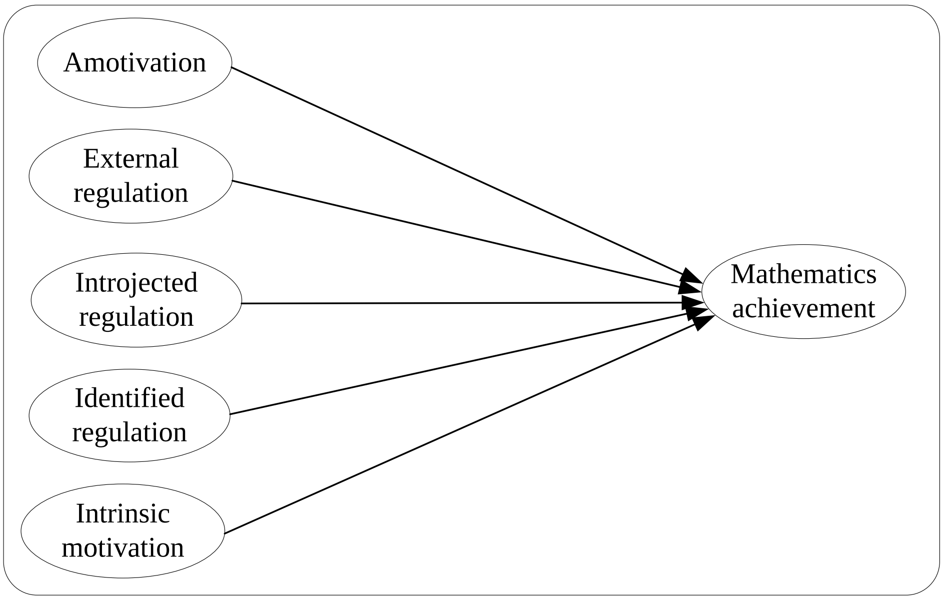

Figure 2. Research model

The literature has indicated that mathematics motivation correlates with academic achievement. Amotivation is correlated with negative outcomes (Deci & Ryan, 2000). Further, Flammer and Schmid (2003) found that extrinsic motivation positively influences students' academic achievement. Identified regulation, introjected regulation and external regulation are different forms of extrinsic motivation. Moreover, many studies have discovered the correlation between intrinsic motivation and positive academic performance (Deci et al., 1991; Grolnick et al., 1991). Therefore, the following hypotheses were developed:

Hypothesis 1 (H1): Amotivation negatively correlates with mathematics achievement.
Hypothesis 2 (H2): External regulation positively correlates with mathematics achievement.
Hypothesis 3 (H3): Introjected regulation positively correlates with mathematics achievement.
Hypothesis 4 (H4): Identified regulation positively correlates with mathematics achievement.
Hypothesis 5 (H5): Intrinsic motivation positively correlates with mathematics achievement.

Data Collection Instrument

Mathematics Motivation

This study adopted the AMTMS (Lim & Chapman, 2015a). The AMTMS has 21 measurement items, including four for each latent variable—amotivation, external regulation, introjection and identification—and five for intrinsic motivation (Table 1). The main question of the AMTMS is 'Why do you spend time studying mathematics?'. The participants were asked to rank the AMTMS items using a 5-point Likert scale (1 = 'strongly disagree' to 5 = 'strongly agree').

Mathematics Achievement

The study used the mathematics results of the National High School Graduation Examination, 2019. The results from 2019 were used because, at the time of the current survey, they were the most recent. The pen-and-paper mathematics examination ran for a period of three hours and students used the results to apply for entry into college or university. To obtain its data, the study utilised the self-reporting of grades by participants. A ten-point grading scale is used in the Vietnamese education system.

Participants

The target participants were students who undertook the National High School Graduation Examination, 2019. The final sample ($N = 680$) comprised 367 females, 305 males and eight others. The self-reported grades (mathematics achievement) ranged from 0 to 10, in which the mean values were 7.28 (out of 10) with a standard error of 0.051 and standard deviation of 1.343. In all, 93.8% of the participants were enrolled in a higher education course, among whom 92.2% were enrolled at a university for a bachelor's degree, and the remaining had opted for vocational training or a diploma course. Surprisingly, 85.9% of participants informed that their mathematics scores had been used in their combination of subject scores to apply for entry to university.

Data Analysis Method

Descriptive data analysis was undertaken to assess the fundamental characteristics of the data. A visual inspection and statistical assessment confirmed that the data were normally distributed. Thereafter, structural equation modelling was used for data analysis, in which the maximum likelihood estimation method was used. Confirmatory factor analysis (CFA) was applied to the measurement model for confirming the reliability and fitness of the factor structures of the latent variables. Structural equation modelling was used to test the hypotheses on the correlations between mathematics motivation and achievement. The following indicators were adopted to evaluate the model fit: the chi-squared test (χ^2), the comparative fit index (CFI), the Tucker–Lewis index (TLI), the standardised root mean square residual and the root mean square error of approximation (RMSEA) (Kline, 2015). The model is considered to have an acceptable fit when these indices satisfy the following conditions: CFI and TLI > 0.90 (Hoyle & Panter, 1995) and RMSEA < 0.08 (Hair et al., 2014).

RESULTS AND DISCUSSION

Validity and Reliability Analysis

In this study, IBM SPSS AMOS Graphics Version 26 was used for CFA, for all measurement items. Convergent validity was assessed using the factor loadings, *t*-values and *p*-values of each indicator. As presented in Table 1, the factor loadings for all the measurement variables were statistically significant at 0.001 (the unstandardised estimates are reported). The correlation values, average variance extracted (AVE) scores and the AVE square root scores were used for assessing discriminant validity.

Table 1. Measurement variables and their factor loadings

Label	Variable	β	$t-value$
Question: Why do you spending time studying mathematics?			
Amotivation (AMOT)			
AMOT1	Honestly, I don't know; I feel that it is a waste of time studying mathematics.	0.948***	22.098
AMOT2	I can't see why I study mathematics and frankly, I couldn't care less.	1.000	
AMOT3	I don't know; I can't understand what I am doing in mathematics.	0.930***	21.132
AMOT4	I am not sure; I don't see how mathematics is of value to me.	0.882***	19.875
External regulation (EXTE)			
EMER1	Because without a good grade in mathematics, I will not be able to find a high-paying job later on.	0.800***	18.180
EMER2	In order to obtain a more prestigious job later on.	0.931***	27.565
EMER3	Because I want to have "the good life" later on.	0.941***	29.192
EMER4	In order to have a better salary later on.	1.000	
Introjected regulation (INTRO)			
EMIN1	Because of the fact that when I do well in mathematics, I feel important.	0.515***	12.987
EMIN2	Because I want to show to others (e.g., teachers, family, friends) that I can do mathematics.	0.821***	19.498
EMIN3	To show myself that I am an intelligent person.	1.000	
EMIN4	Because I want to show myself that I can do well in mathematics.	0.985***	23.356
Identified regulation (IDEN)			
EMID1	Because I think that mathematics will help me better prepare for my future career.	1.000	
EMID2	Because studying mathematics will be useful for me in the future.	0.966***	26.546
EMID3	Because I believe that mathematics will improve my work competence.	0.907***	24.144
EMID4	Because what I learn in mathematics now will be useful for the course of my choice in university.	0.966***	23.501
Intrinsic motivation (INTRI)			
IMTA4	Because I want to feel the personal satisfaction of understanding mathematics.	0.943***	28.935
IMTK2	For the pleasure I experience when I discover new things in mathematics that I have never learnt before.	0.976***	31.862

Label	Variable	β	$t-value$
IMTK3	For the pleasure that I experience in broadening my knowledge about mathematics.	1.000	
IMTS2	For the pleasure that I experience when I learn how things in life work, because of mathematics.	0.929***	25.235
IMTS3	For the pleasure that I experience when I feel completely absorbed by what mathematicians have come up with.	0.945***	23.087

Figure 3 illustrates the CFA model and Table 2 shows the test results. As shown, the composite reliability (CR) values for all latent constructs exceeded 0.80 (0.823–0.913), which proves strong reliability. Convergent validity was confirmed as the AVE values were above 0.50 (0.547–0.677). The square roots of the AVE were higher than its correlation; thus, discriminant validity was confirmed. The TLI (0.090) and CFI (0.922) were higher than 0.90 and RMSEA (0.078) was smaller than 0.08; thus, the CFA model had an acceptable fit.

Table 2. Validity and reliability analysis results

Model Measures	Validity	CR	AVE	AMOT	EXTE	INTRO	IDEN	INTRI
AMOT		0.860	0.606	0.779				
EXTE		0.879	0.649	-0.344***	0.806			
INTRO		0.832	0.547	-0.355***	0.475***	0.740		
IDEN		0.891	0.671	-0.587***	0.718***	0.523***	0.819	
INTRI		0.913	0.677	-0.581***	0.416***	0.606***	0.673***	0.823

Note: $*p < 0.10$, $**p < 0.05$, $***p < 0.001$. Model fit indices: $\chi^2 = 914.868, df = 179, p = 0.000, \chi^2/df = 5.111, TLI = 0.909, CFI = 0.922$, RMSEA = 0.078.

Figure 3 presents the CFA of a five-factor model comprising AMOT, EXTE, INTRO, IDEN and INTRI. In addition, the figure shows the correlation results between latent variables. AMOT has a significant and negative correlation with EXTE, INTRO, IDEN and INTRI, whereas EXTE, INTRO, IDEN and INTRI have a significant and positive correlation with each other.

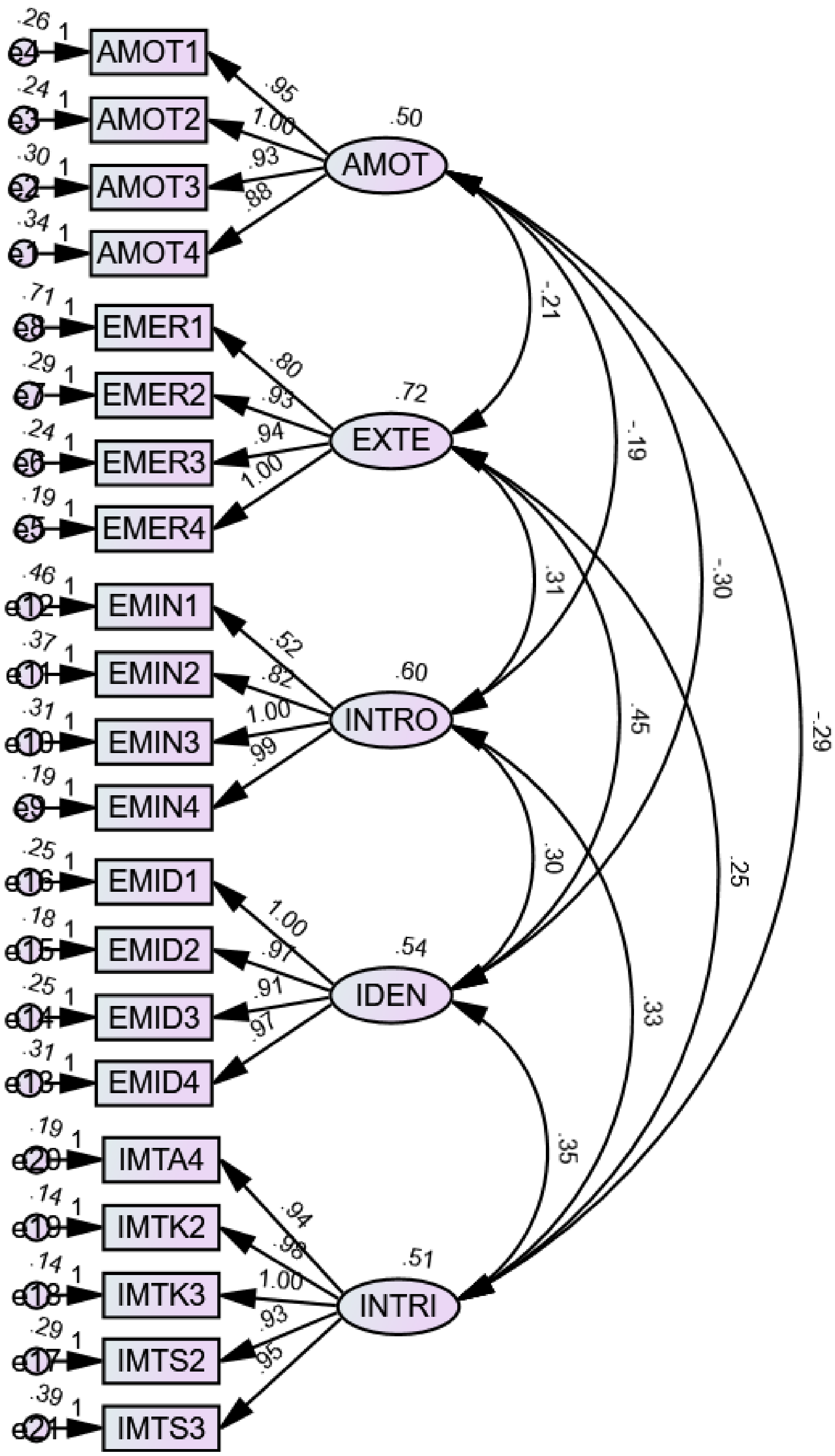

Figure 3. CFA model

Relationship between Mathematics Motivation and Mathematics Achievement

Figures 4–8 present the relationships between (1) AMOT, EXTE, INTRO, IDEN and INTRI and

(2) MA, respectively. The test results are presented in Table 3. Table 3 provides information on the dependant variable, independent variable, model fit indices and path indices for each testing model. The results are unstandardised estimations. The path models representing these relationships were run separately to test the hypotheses.

Amotivation

Figure 4 presents a model for testing the direct relationship between AMOT and MA, in which AMOT negatively correlates with MA.

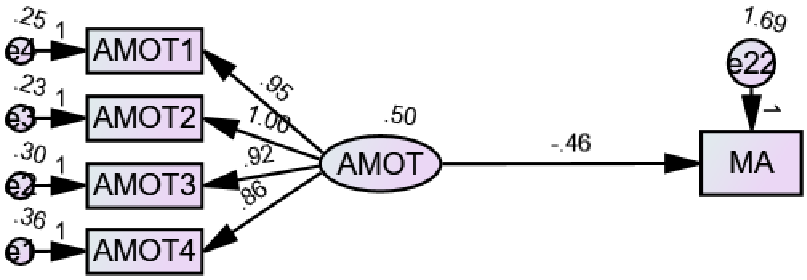

Figure 4. Relationship between amotivation and mathematics achievement

The results in Table 3 suggest a significant and negative correlation between AMOT and MA ($\boldsymbol{\beta = -0.462, t - value = -5.999, \rho < 0.001}$), thus supporting H1—'Amotivation negatively correlates with mathematics achievement'.

External Regulation

Figure 5 shows the model used to test for a direct relationship between EXTE and MA.

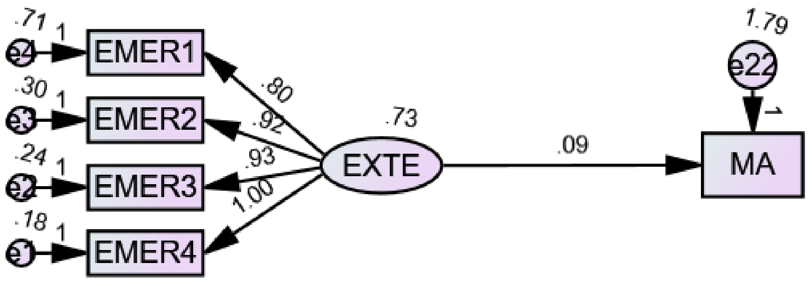

Figure 5. Relationship between external regulation and mathematics achievement

The results in Table 3 show there is no significant correlation between EXTE and MA ($\boldsymbol{\beta = 0.088, \rho = 0.164}$). Therefore, H2 was rejected.

Introjected Regulation

Figure 6 presents a model for testing the direct relationship between INTRO and MA, in which INTRO positively correlates with MA.

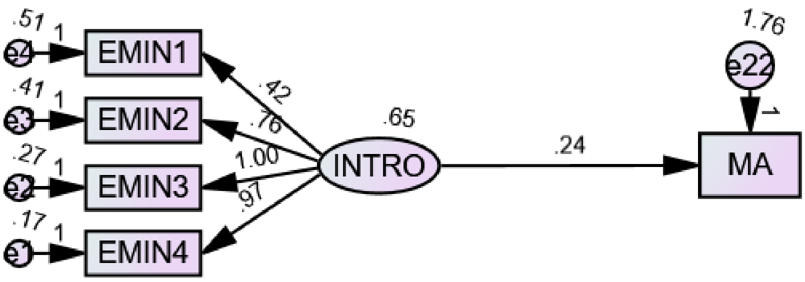

Figure 6. Relationship between introjected regulation and mathematics achievement

The results in Table 3 illustrate a significant and positive correlation between INTRO and MA ($\boldsymbol{\beta = 0.236, t - value = 3.418, \rho < 0.001}$), thus supporting H3—'Introjected regulation positively correlates with mathematics achievement'.

Identified Regulation

Figure 7 shows a model for testing the direct relationship between IDEN and MA, in which IDEN positively correlates with MA.

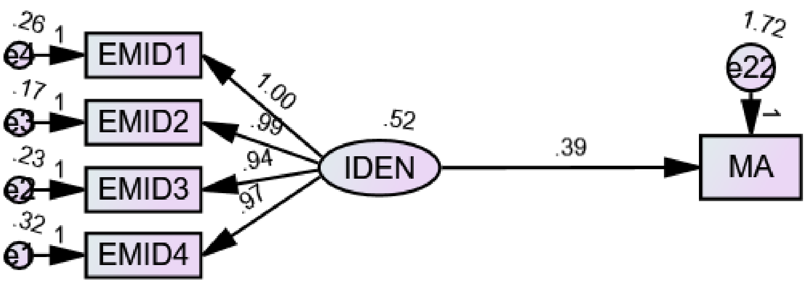

Figure 7. Relationship between identification and mathematics achievement

The Table 3 results show a significant and positive correlation between IDEN and MA ($\boldsymbol{\beta = 0.389, t - value = 5.217, \rho < 0.001}$), thus supporting H4—'Identified regulation positively correlates with mathematics achievement'.

Intrinsic Motivation

Figure 8 presents a model for testing the direct relationship between INTRI and MA, in which INTRI positively correlates with MA.

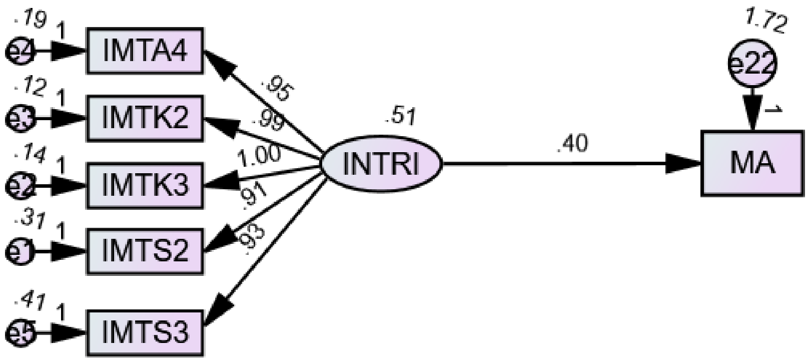

Figure 8. Relationship between intrinsic motivation and mathematics achievement

As the results in Table 3 show, there was a significant and positive correlation between INTRI and MA ($\boldsymbol{\beta = 0.402, t - value = 5.433, \rho < 0.001}$). Therefore, H4—'Intrinsic motivation positively correlates with mathematics achievement'—was supported.

Table 3. Relationship between mathematics motivation and mathematics achievement

Model	**Variables**		**Model Fitting Indexes**				**Path Indexes**		
	DV	IV	**ρ**	$\boldsymbol{\chi^2/df}$	CFI	RMSEA	$\boldsymbol{\beta}$	t-value	P
1	AMOT	MA	0.000	9.757	0.966	0.114	-0.462^{***}	–5.999	0.000
2	EXTE	MA	0.000	15.893	0.952	0.148	0.088^{n}	1.392	0.164
3	INTRO	MA	0.000	13.937	0.941	0.138	0.236^{***}	3.418	0.000
4	IDEN	MA	0.044	2.279	0.996	0.043	0.389^{***}	5.217	0.000
5	INTRI	MA	0.000	7.099	0.976	0.095	0.402^{***}	5.433	0.000

Note: *$p < 0.10$; **$p < 0.05$; ***$p < 0.001$; n: non-significant; DV: dependant variable; IV: independent variable.

Table 3 presents a summary of the research outcomes. As seen in H1, the study revealed that amotivation negatively correlates with mathematics achievement. This result suggests that higher levels of amotivation may lead to decreased mathematics performance in an individual. This finding is in line with Lim and Chapman (2015a) research, whereby amotivation is negatively associated with mathematics achievement among Year 11 and 12 mathematics students in Singapore. Amotivation was characterised by four measurement indicators: 'It is a waste of time studying mathematics' (AMOT1), 'I cannot see why I study mathematics' (AMOT2), 'I cannot understand what I am doing in mathematics' (AMOT3) and 'I do not see how mathematics is of value' (AMOT4). Deci and Ryan (2000) stated that amotivation is correlated with many highly negative outcomes. Further, according to self-determination theory, amotivation results in negative consequences (Tiwari et al., 2014). Thus, the present study's finding is in line with that of prior research, which refer to amotivation as a state in which people lack the aim to perform a particular action and either act without intent or do not act at all (Ryan & Deci, 2000b).

As anticipated in H3, the findings of the present study found that introjected regulation positively correlates with mathematics achievement. Although Lim and Chapman (2015a) did not find any statistically significant correlation between introjection and mathematics achievement, the current study revealed a positive correlation between introjected regulation and mathematics achievement. Introjected regulation was characterised by four measurement items: 'When I do well in mathematics, I feel important' (EMIN1), 'I want to show others that I can do mathematics' (EMIN2), 'I want to show myself that I am intelligent person' (EMIN3) and 'I want to show myself that I can do well in mathematics' (EMIN4). Introjected regulation is one kind of extrinsic motivation (Deci & Ryan, 2000). Students with an extrinsic orientation see tasks as a means to an end and complete tasks for a reason, for instance, for grades, performance or rewards that are evaluated by others (Pintrich, 1991; Herges et al., 2017). Studies prove that extrinsic motivation affects adolescent academic performance (Herges et al., 2017). Flammer and Schmid (2003) discovered that extrinsic motivation has a positive influence on students' academic achievement. It is critical to note that different age groups of adolescent students are motivated differently (Herges et al., 2017). Further, Woolley et al. (2010) assumed that early adolescents may identify extrinsic motivation as essential as students try to please their parents and teachers.

As anticipated in H4, identified regulation positively affects mathematics achievement. This substantiates previous findings in the literature, whereby identification positively correlates with mathematics achievement. Identified regulation was characterised by four items: 'I think that mathematics will help me better prepare for my future career' (EMID1), 'Studying mathematics will be useful for me in the future' (EMID2), 'I believe that mathematics will improve my work competence' (EMID2) and 'What I learn in mathematics now will be useful for the course of my choice in university' (EMID4). This concurs with Lim and Chapman (2015a) research, wherein identification significantly and positively affects mathematics achievement.

As seen in H5, intrinsic motivation positively affects mathematics achievement. The result suggests that the greater the inner desire to study the subject, the better the mathematics performance. Our results share a number of similarities with those of Lim and Chapman (2015a), for whom intrinsic motivation has a positive correlation with mathematics achievement in Grades 11 and 12 in Singapore. In this present study, intrinsic motivation was measured by five items (Table 1): 'I want to feel the personal satisfaction of understanding mathematics' (IMTA4), 'For the pleasure I experience when I discover new things in mathematics that I have never learnt before' (IMTK2), 'For the pleasure that I experience in broadening my knowledge about mathematics (IMTK3), 'For the pleasure that I experience when I learn how things in life work, because of mathematics' (IMTS2) and 'For the pleasure that I experience when I feel completely absorbed by what mathematicians have come up with' (IMTS3). Ryan and Deci (2000a) stated that intrinsic motivation may create high-quality learning and creativity; thus, supporting school environments in which intrinsic motivation is promoted is vital for ensuring this outcome. Ryan and Deci (2000a) cautioned that people may overestimate the degree of extrinsic motivation and undermine intrinsic motivation, such as through external regulation that results in a low level of autonomy. However, other extrinsic motivations, such as integrated regulation, introjected regulation and identification, are considered to have the same positive effects as intrinsic motivation (Lim & Chapman, 2015a). The current study results reinforce this argument, in which introjected regulation and identification positively affect mathematics achievement.

Interestingly, as seen in Table 3, the regression coefficients between i) amotivation (AMOT), external regulation (EXTE), introjection (INTRO), identification (IDEN) and intrinsic motivation (INTRI) and ii) mathematics achievement increase by –0.462***, 0.088n, 0.236***, 0.389*** and 0.402***, respectively. These results can be explained by self-determination theory (Ryan & Deci, 2000b), whereby people with higher levels of self-determination tend to perform better. Individuals are more motivated when they feel autonomous (Svinicki, 2010). However, the positive relationship between introjected regulation and mathematics achievement differs from that found in previous studies, in which no significant relationship was observed between introjected regulation and mathematics achievement (Lim & Chapman, 2015a). The difference can be explained by the role of mathematics in the overall curriculum in Vietnam. Mathematics is one of three compulsory subjects in the National High School Graduation Examination. Further, in Vietnam, people who are good at mathematics are often viewed as smart. Therefore, students are encouraged to prove ability in studying mathematics. There is some internal driver; however, 'introjected behaviours still have an external perceived locus of causality and are not really experienced as part of the self' (Ryan & Deci, 2000b, p. 72).

External regulation, introjected regulation, identified regulation and integrated regulation are types of extrinsic motivation. Not all extrinsic motivations positively affect mathematics achievement and the regression coefficients between the latent variables and mathematics achievement were smaller than those between intrinsic motivation and mathematics achievement. Therefore, the role of mathematics teachers is critical and teachers' instructional practices play an important role in encouraging students in learning mathematics. Moreover, Skaalvik et al. (2017) discovered that intrinsic values are positively correlated with the mastery goal structure. They noted that a combination of mastery goal and performance goal structures is often applied in teachers' instructional practices. A mastery goal structure aims at emphasising students' effort, understanding and improvement and considers mistakes to be part of the development process. Thus, students' improvement is used to define their success (Sproule et al., 2007; Skaalvik et al., 2017).

There are several methods that can be applied to foster mastery orientation. These include (i) giving students choices; (ii) modelling a mastery approach; (iii) emphasising learning from mistakes; (iv) providing positive, diagnostic feedback that focuses on personal development; (v) minimising comparisons with other students and emphasise comparisons with previous performance; and (vi) fostering a community within the classroom (Svinicki, 2010). Giving students a choice allows them some control over their own fate (Deci & Ryan, 1985). Regarding the modelling of a mastery approach, Svinicki (2010) suggested that a teacher needs to inform students that if they make a mistake, they can view it as a learning experience, rather than try to avoid or hide it. Teachers should show their students strategies that involve successfully coping with failure so that they can learn ways to handle their own failures (Bandura, 1986). It is also noted that when people know how to cope with failure successfully, they are more confident and less likely to fear or avoid it. Regarding emphasising learning from mistakes, Svinicki (2010) suggested that teachers should allow students to have a chance to correct and learn from their mistakes. For example, if students lose marks in an exam, they should have a chance to redo it; however, they should also explain why they were wrong, and why their current answers are right. If they are able to do this, they should be awarded half a mark for each of the marks that they lost. Regarding giving positive, diagnostic feedback that focuses on personal development, Svinicki (2010) recommended that teachers should not only point out that something is wrong, but also reveal how to correct it. When providing positive feedback, teachers should compare students' current levels to their previous performances and emphasise areas that show improvement. Regarding minimising comparisons with other students and emphasising comparisons with previous performance, one strategy is to make individual performance outcomes more private (Elliot & Murayama, 2008). Regarding fostering community within the classroom, organising a classroom a safe place is very important because a good learning environment encourages students to perceive others as resources and supports rather than as competitors (Svinicki, 2010). For instance, teachers may encourage students to work in groups and then to consult with other groups while working through problems. Importantly, teachers should encourage all students in the class to treat individuals with respect (Svinicki, 2010).

Further, Tran and Nguyen (2020) stated that using technology that is effective in improving mathematics engagement plays a critical role in teaching and learning mathematics. They argued that such application of technology may encourage more collaboration between educators and learners. Thus, the engagement facilitates problem-solving and flexible thinking. They suggested that applications that allow interactive options, such as number lines, number frames and geoboards, should be developed based on advanced technologies and the Internet of Things. Moreover, the use of virtual whiteboards and websites may enable students to share and link ideas as well as visualise concepts. Virtual reality should be applied in teaching and learning mathematics to enable students to observe three-dimensional geometry, which would thus assist and encourage them to learn mathematics.

CONCLUSION

Several key findings were revealed by the current study. Amotivation was proven to negatively correlate with mathematics achievement. However, introjected regulation, identified regulation and intrinsic motivation were shown to positively correlate with mathematics achievement. To the best of the authors' knowledge, this is the first study to have examined the correlation between mathematics motivation and mathematics achievement among graduate high school students in Vietnam. The analysis results proved that both internal and extrinsic motivation (introjected regulation and identified regulation) positively affect mathematics achievement. The findings provide a strong theoretical foundation to improve mathematics achievement by encouraging teachers to develop motivational conditions in mathematics classrooms in Vietnam. The study discussed certain strategies for improving mathematics achievement, such as ways to foster mastery orientation and apply effective technology.

Nevertheless, the study has some limitations. However, it could be a starting point for investigating mathematics affective domains in developing countries and, in particular, in Vietnam. The key limitation results from the fact that most of the participants had studied at a university, even though the study sought to target a wider range of respondents by considering those who had undertaken the National High School Graduation Examination in 2019. Thus, the results may be valid only for this particular group—those who have studied at a university—and generalisation to a wider group should be undertaken with care. In addition, the current study was not specifically designed to collect data on students' learning environments. These limitations may leave room for further studies.

In particular, studies need to be conducted to investigate the relationship between other affective domains (e.g. engagement, anxiety, identity, attitudes and beliefs) and mathematics achievement in Vietnam. With the advancement of technology, future studies should also explore the efficiency of incorporating technology to motivate and engage students in mathematics education. Further, the moderating effect of students' learning environment on the correlations between affective domains and mathematics achievement should be explored.

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