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Research Article

THE MULTILEVEL MEDIATING EFFECTS OF TEACHER TRAINING AND EXTENSION COURSES ON THE RELATIONSHIPS AMONG TEACHER SUPPORT, MOTIVATION, AND SELF-EFFICACY IN MATHEMATICS

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ABSTRACT

Mathematics is fundamental knowledge that students can adopt on a regular basis as well as in future careers. It also allows students to think systematically and rationally, enhancing problem-solving skills (OECD., 2023). The current research aimed to 1) analyze multilevel mediating effects of teacher training and extension courses on the relationships among teacher support, motivation, and self-efficacy in mathematics. 2) study instruction to enhance motivation and self-efficacy in mathematics. Secondary data were adopted from PISA 2022, in the study of 6,196 students in Thailand who studied in 280 schools of all types. The data were then analyzed using MSEM by the Mplus program. The results revealed that the structural equation model of multilevel mediating effects of teacher training and extension courses on the relationships among teacher support, motivation, and self-efficacy in mathematics had a good fit with the empirical data. The statistical values were ($\chi^2(1, N=6196)=3.48$, $p=0.062$, CFI=0.997, TLI=0.980, RMSEA=0.020). The student-level model had full mediation in which teacher support had an indirect effect via motivation with a statistical significance of .05 and motivation had a direct effect on self-efficacy with a statistical significance of .05. In the school-level model, it was discovered that teacher training and extension courses had a direct effect on self-efficacy and motivation with no statistical significance of .05 and the participants of all instructions had higher averages for motivation and self-efficacy than those of non-participants.

Keywords: Motivation, Self-efficacy, Teacher Support, Extension Courses, Teacher Training

INTRODUCTION

The Organisation for Economic Co-operation and Development (OECD) established an assessment project for students which was a global effort globally recognized as PISA with the aim to measure students' proficiency and to improve the education quality. Mathematics is considered fundamental knowledge that can be adopted on a regular basis such as making payments, reading receipts and understanding contracts. In addition, mathematical knowledge can facilitate the knowledge acquisition of other areas including understanding science via mathematics. It also allows learners to organize their own thoughts, think logically, and solve problems (OECD., 2022). For this reason, mathematics is a versatile and practical tool in life that should be possessed by learners; therefore, academics aimed to help students achieve effective mathematical outcomes as an ultimate goal (Lee et al., 2018). Even though mathematics is of utmost importance, a great portion of students tends to develop the idea that it is a difficult subject even before trying to understand the core of the subject because they lack motivation and have a negative attitude toward the subject (Higgins et al., 2003). It is worth pointing out that the results of the Programme for International Student Assessment: PISA developed by OECD in 2000 showed that Thai students have achieved lower than the global average outcome (OECD., 2019a; 2019b).

The ability to learn effectively starts from having self-efficacy which is definitely achievable because it influences behavioral change and the decision to do a particular activity with consistency (Bandura, 1977). The study of relevant documents and research studies illustrates that students' self-efficacy in learning is influenced by motivation (Affuso et al., 2023) which includes intrinsic motivation stemming from passion and extrinsic motivation from realizing the significance of mathematics in other areas. Additionally, it has been discovered that the change in the individual belief system and behaviors based on the social cognitive theory is composed of three coherent components (Triadic reciprocity) including a person, an environment, and a behavior which give rise to individual learning. Therefore, many academics have shown research studies indicating that changes in the individual belief system and behaviors come from teacher support, academic support, lifestyles, and inspiration that have a strong impact on students' motivation (MacIntyre & Blackie, 2012).

Thai government has recognized the significance of mathematics and has imposed the policy of the Basic Education Development Plan of 2023-2027 in which each school has extension courses for mathematics in order that learners accomplish more advanced mathematics and see the values of mathematics, serving as an important tool generating the motivation to learn mathematics (Office of the Basic Education Commission, Ministry of Education, 2022).Schools are also required to give importance to mathematics to offer students with academic support, creating confidence in mathematics. Schools also see the importance of teachers in developing knowledge and abilities and motivation; as a result, teacher training programs exist. It is further discovered that the mentioned factors are separated and in a student level. Nevertheless, teacher training and extension courses in mathematics are school-level factors. To answer questions and find out direct and indirect effects of self-efficacy, a multilevel structural equation model (MSEM) is adopted in mathematics.

Furthermore, the Programme for International Student Assessment (PISA) in 2022 measured mathematical abilities in which the measuring framework was adjusted to conform to the changing situations of the current world with an addition of learning in the digital world (OCDE, 2023). The data collection was implemented during the spread of the COVID19 pandemic (Zhao, & Watterston, 2021).Learners started to develop a changing learning pattern during the time making it intriguing to explore instructions that create motivation and help learners recognize their mathematical abilities. The information was employed in the pursuit of enhancing and supporting Thai students' mathematical abilities.

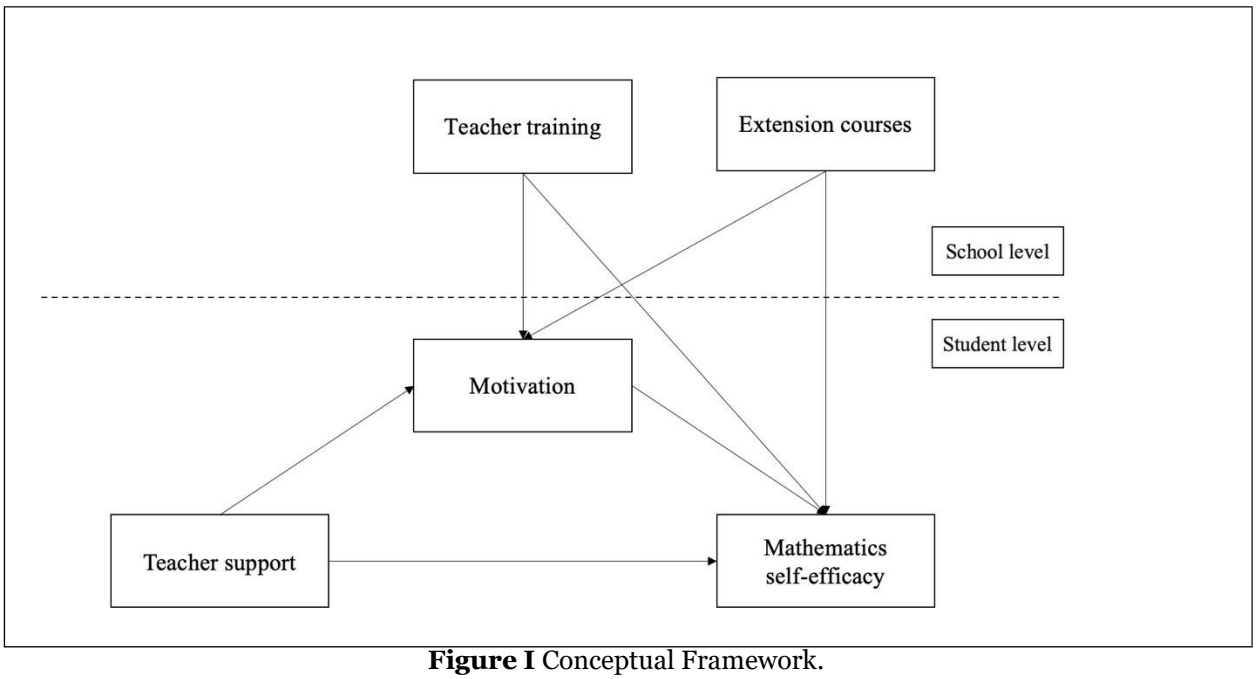

Figure I Conceptual Framework.

METHODOLOGY

The current research endeavor adopted secondary data from the Programme for International Student Assessment (PISA) which is a worldwide study conducted by the Organisation for Economic Co-operation and Development (OECD) that evaluates educational systems by measuring 15-year-old students' performance in reading, mathematics, and science. The assessment is carried out every three years, providing data that can be used to compare educational systems globally and assess the effectiveness of education policies.

1) DATA

PISA's target population in each country consisted of 15-year-old students attending educational institutions in grade 7 and higher. The internatonal requirement was that the assessment had to be conducted during a 6-day period, referred to as the testing period, between March 1st, 2022 and October 31st, 2022. The research

relied on random sampling using strict stratification of student proportions in each school based on the Guidelines in the Sampling in PISA manual (OECD, 2022). Files of students' data and school information were employed via the website in the link https://www.oecd.org/pisa/data/2022database/. There were 8,459 Thai students participating in the test. After organizing the missing data using the listwise deletion and selecting only the information of Thai students who took the PISA 2022 test using Program R as well as variables for the research consisting of school codes, teacher training, extension courses, motivation, self-efficacy, and teacher support. Therefore, the population was reduced to 6,196 Thai students who took the PISA 2022 test.

2) VARIABLES

The variables were selected from the data in PISA 2022 measured by tests and questionnaires developed by a group of experts around the world who evaluated PISA of OCED. The current research study studied five variables in PISA 2022, two of which were school-level variables which were extension courses and teach training, while student-level variables included teacher support, motivation, and self-efficacy. Definitions were given based on PISA 2022 (OECD, 2022).

2.1) Teacher training

the research collect Teacher training variable pass "mathematics teacher training" from PISA 2022. The school representatives answered the question item saying "Does your school offer professional development to mathematics teachers in any of the following?". There were a total of six questions.

TABLE I Questions in the PISA questionnaire measuring mathematics teacher training.

CODE	PISA test questions
SC184Q01JA	Mathematics content
SC184Q02JA	Mathematics pedagogy/instruction
SC184Q03JA	Mathematics curriculum
SC184Q04JA	Integrating digital resources into mathematics instruction
SC184Q05JA	Improving students' critical thinking or problem solving skills
SC184Q06JA	Mathematics assessment

2.2) Extension courses

Extension courses collect by " extension courses offered at school" from PISA 2022. The results were selected via the question item "What types of additional mathematics lessons are offered? ". Schools answered three questions overall.

TABLE II Questions in the PISA questionnaire measuring mathematics extension courses.

CODE	PISA test questions
SC181Q01JA	Enrichment
SC181Q02JA	Remedial
SC181Q03JA	Without differentiation depending on the prior achievement level of the students

2.3) Motivation

Motivation collect by "relative motivation to do well in mathematics" in PISA 2022..Which Students answered three questions in the form of a 4-Likert scale (Never, A few times, About once or twice a week, Every day or almost every day).TABLE II PISA test questions about motivation.

TABLE III Questions in the PISA questionnaire measuring motivation.

CODE	PISA test questions
ST268Q01JA	Mathematics is one of my favourite subjects.
ST268Q04JA	Mathematics is easy for me.
ST268Q07JA	I want to do well in my mathematics class.

2.4) Mathematics self-efficacy

Self-efficacy in this study collect from item about Mathematics self-efficacy in PISA 2022. Which Students answered ten questions in the form of a 4-Likert scale (Never, A few times, About once or twice a week, Every day or almost every day).

TABLE IV Questions in the PISA questionnaire measuring mathematics self-efficacy.

CODE	PISA test questions
ST291Q01JA	How confident in math tasks: Extracting mathematical information from diagrams, graphs, or simulations
ST291Q02JA	How confident in math tasks: Interpreting mathematical solutions in the context of a real-life challenge
ST291Q03JA	How confident in math tasks: Using the concept of statistical variation to make a decision
ST291Q04JA	How confident in math tasks: Identifying mathematical aspects of a real-world problem
ST291Q05JA	How confident in math tasks: Identifying constraints and assumptions behind mathematical modelling
ST291Q06JA	How confident in math tasks: Representing a situation mathematically using variables, symbols, or diagrams
ST291Q07JA	How confident in math tasks: Evaluating the significance of observed patterns in data
ST291Q08JA	How confident in math tasks: Coding/programming computers

CODE	PISA test questions
ST291Q09JA	How confident in math tasks: Working with computer systems (e.g. spreadsheets, programming software, graphing calculators)
ST291Q10JA	How confident in math tasks: Calculating the properties of an irregularly shaped object

2.5) Teacher support

Teacher support collect by "Mathematics teacher support" in PISA 2022.There were four questions measuring teachers via students' perspective in the form of a 4-Likert scale (Every lesson, Most lessons, Some lessons, Never or almost never).

TABLE V Questions in the PISA questionnaire measuring mathematics teacher support.

CODE	PISA test questions
ST270Q01JA	The teacher shows an interest in every student's learning.
ST270Q02JA	The teacher gives extra help when students need it.
ST270Q03JA	The teacher helps students with their learning.
ST270Q04JA	The teacher continues teaching until the students understand.

ANALYSIS

The current research study adopted a statistical analysis to answer the research questions using Multilevel Structural Equation Modeling: MSEM via M-plus Version 8 and Multivariate Analysis of Variance: MANOVA using SPSS Version 22.

RESULTS

The results of the analysis of the multilevel mediating effects of teacher training and extension courses on the relationships among teacher support, motivation, and mathematics self-efficacy revealed that the proportion of variance in the student-level dependent variables of the observation variable which is an index of the appropriateness of multi-level model analysis ranged from .05-.07, all of which exceeded .05, indicating the student-level dependent variables obtained a sufficient proportion of variance for the analysis of a multilevel model. The results revealed that the structural equation model of multilevel mediating effects of teacher training and extension courses on the relationships among teacher support, motivation, and self-efficacy in mathematics had a good fit with the empirical data. The statistical values were ($\chi^2(1, N=6196)=3.48$, $p=0.062$, CFI=0.997, TLI=0.980, RMSEA=0.020)considered from the conformity index based on (Hooper, Coughlan, & Mullen, 2008).

The results of the analysis of the multi-level model influence of teacher training and extension courses on the relationships among teacher support, motivation, and self-efficacy in mathematics demonstrated that motivation on the lesson had a direct effect on self-efficacy with a statistical significance of .05 ($\beta=0.224$) and teacher support had a direct effect on self-efficacy with no statistical significance of .05($\beta=0.007$). However, teacher support was shown to have indirect effect ($\beta=-0.046$) and total effect ($\beta=-0.039$) via motivation with a statistical significance of .05. This reflects that the student-level model was in full mediation with motivation. The study of the school-level influence illustrated that teacher training ($\beta=-0.159$) and extension courses ($\beta=0.046$) had a direct effect on self-efficacy with no statistical significance of .05 and teacher training ($\beta=-0.142$) and extension courses ($\beta=-0.053$) had a direct effect on motivation statistical significance of .05. Only the school-level motivation had a direct effect on school-level self-efficacy with a statistical significance of .05 ($\beta=0.831$), indicating that schools in Thailand that had already improved in teacher training and extension courses in mathematics failed to cultivate motivation and self-efficacy in mathematics.

TABLE VI The direct, indirect and total effects of multilevel mediating effects of teacher training and extension courses on the relationships among teacher support, motivation, and self-efficacy.

	Level 1 : Student level						**Level 2 :** School level					
Dependent Variables	Motivation			Mathematics self-efficacy			Motivation			Mathematics self-efficacy		
Independent Variables	DE	IE	TE	DE	IE	TE	DE	IE	TE	DE	IE	TE
Teacher Training							-0.142 (0.122)		-0.142 (0.122)	-0.159 (0.103)		-0.159 (0.103)
extension courses							0.053 (0.093)		0.053 (0.093)	0.046 (0.082)		0.046 0.082
motivation				0.414* (0.014)		0.414* (0.014)				0.831* (0.055)		0.831* (0.055)
teacher support	-0.111* (0.016)		-0.111* (0.016)	0.007 (0.014)	-0.046* (0.007)	-0.039* (0.016)						
($\chi^2(1, N=6196)=3.48$, $p=0.062$, CFI=0. 0.997, TLI=0.980, RMSEA=0.020, SRMR for Within = 0.017, SRMR for Between = 0.021)												
Variable	Motivation			Mathematics self-efficacy			Motivation			Mathematics self-efficacy		
R^2	0.012			0.171			0.012			0.171		

*$p < .05$ (The numbers shown are standard scores), DE = Direct effect, IE = Indirect effect, TE = Total effect

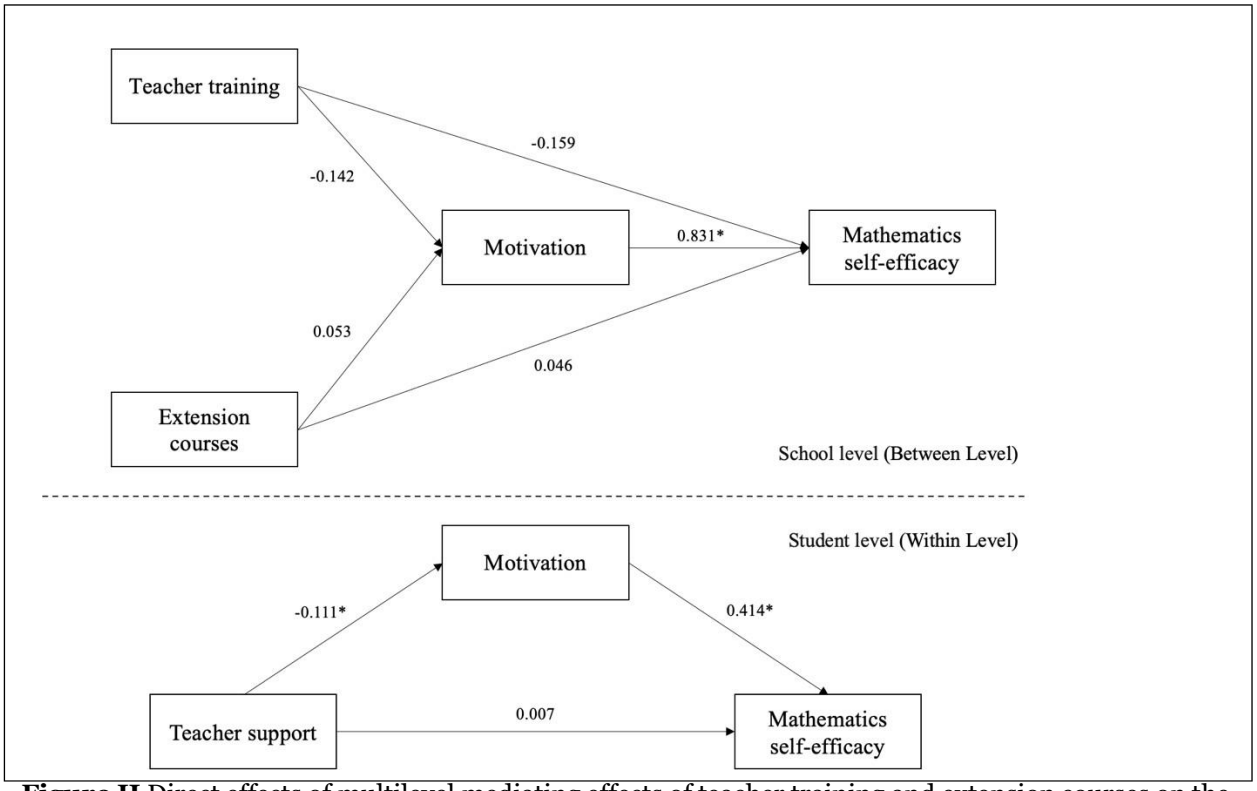

Figure II Direct effects of multilevel mediating effects of teacher training and extension courses on the relationships among teacher support, motivation, and mathematics self-efficacy.

The study of instruction to enhance motivation and self-efficacy using a multivariate analysis of variance revealed that Internet or computer tutoring with a programme or application (F(2, 6196) = 21.811, p=0.000, Pillai's Trace = 0.007, partial η^2 = 0.007), video-recorded instrucyion by a person (F(2, 6196) = 16.738, p=0.000, Pillai's Trace = 0.005, partial η^2 = 0.005) and large group study or practice(F(2, 6196) = 13.383, p=0.000, Pillai's Trace = 0.004, partial η^2 = 0.004) had a different average vector between motivation and self-efficacy from other participants, with a statistical significance of .05.

In addition, one-on-one tutoring with a person (F(2, 6196) = 0.167, p=0.846, Pillai's Trace = 0.000, partial η^2 = 0.000) and small group study or practice (F(2, 6196) = 0.172, p=0.842, Pillai's Trace = 0.000, partial η^2 = 0.000) had a different average vector between motivation and self-efficacy from other participants, with a statistical significance of .05. Both multivariate and univariate tests showed that the average of motivation and self-efficacy obtained from participation of various instruction was higher than the non-participation.The details are illustrated in Table VII.

Moreover, after comparing the average of motivation and self-efficacy using Figure III, it was discovered that the participation group of various instruction obtained a higher average. Those who indicated "I do not participate in additional mathematics instruction" showed that each instruction to increase motivation and self-efficacy had a different effect on learners. Nonetheless, the average remained higher than those who did not go through any improvement.

TABLE VII Result comparing multivariate and univariate divided based on instructions.

Instruction	Variable	Mean		Mutivariate		Univariate		Compare
		Parti	Non	Pillai	P	F	P	
One-on-one tutoring with a person	motivation	2.597	2.523	0.000	0.846	Parti>Non		
	self-efficacy	2.355	2.238					
Internet or computer tutoring with a programme or application	motivation	2.631	2.475	0.007	0.000	25.506	0.000	Parti>Non
	self-efficacy	2.380	2.186			35.917	0.000	Parti>Non
Video-recorded instruction by a person	motivation	2.637	2.481	0.005	0.000	25.154	0.000	Parti>Non
	self-efficacy	2.384	2.195			22.425	0.000	Parti>Non
Small group study or practice	motivation	2.598	2.517	0.000	0.842	Parti>Non		
	self-efficacy	2.354	2.229					
Large group study or practice	motivation	2.592	2.527	0.004	0.000	2.668	0.102	Parti>Non
	self-efficacy	2.401	2.223			14.127	0.000	Parti>Non

*Parti=Participate, Non=Non Participate

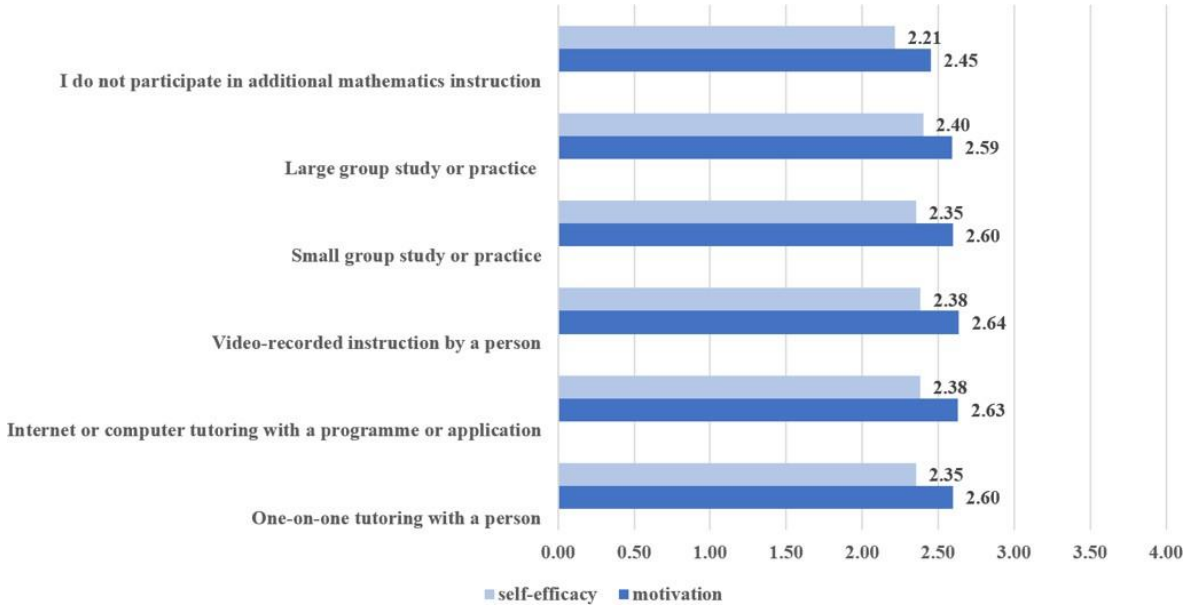

Figure III Average motivation and self-efficacy of those receiving instructions.

DISCUSSION

1. The research results found that motivation had a direct impact on self-efficacy with a statistical significance, which is consistent with the theory explaining that motivation is a crucial factor pertinent to other variables, especially the ability to recognize an individual ability. It is generally known that those who have motivation in a particular matter possess the ability to perceive their own ability in the matter (Rushton, 2001). Hence, to develop students' ability to perceive their own abilities, it is essential that motivation be ignited for them. To accomplish that goal, there are multiple approaches including family-generated motivation, the environment, and teachers, as well as intrinsic motivation which stems from their own passion. Besides, the research results further demonstrated that teacher support had a direct impact on students' perception of their own abilities with no statistical significance, indicating that the perception level largely depends on each individual (Klassen & Chiu, 2010). Nonetheless, even though it was found that teacher support did not have a direct impact on students' perception of their own abilities, it proved to possess an indirect impact on students' perception of their own abilities via motivation with a statistical significance. For this reason, motivation plays a role in full mediation, meaning if teachers aim to encourage students to perceive their own abilities, they necessarily kindle their motivation in the first place (Deci et al., 2013). Educational organizations should find ways to lend their support to teachers in managing their teaching to effectively cultivate students' motivation to learn and accurately perceive their own abilities in diverse areas. This is also claimed to be a driving force for students' academic success.

The research findings from the analysis of the influence of multi-level model variables revealed that regarding the school-level variables, teacher training and extension courses impacted motivation, self-efficacy with no statistical significance, probably because teacher training is a method to enhance vocational abilities prioritizing mathematical teaching management which is not directly relevant to the development of students' skills. Moreover, the curriculum supporting mathematics learning organized by schools emphasizes the acquisition of additional mathematics skills and remedial teaching for students; that being said, because students have their own learning needs, the curriculum is not suitable for individual learning management. This is compatible with research results by Ayllón, Alsina, & Colomer (2019) which found that as students are in a higher educational level, they develop different needs in learning, independence support, structures, engagement, and perception of their own abilities to achieve the optimal potential for success. Still, motivation had a direct impact on self-efficacy with a statistical significance in the school level, reflecting the importance of motivation whether in an individual level or in a school level, which affects students' ability to perceive their own abilities.

2. Instructions could influence students' motivation and self-efficacy. The research results discovered that the participants engaged in the instruction in Table 6 obtained higher averages for motivation and self-efficacy than those of the non-participants with a statistical significance. This indicates that teaching designs and methods are a crucial aspect to enhance students' motivation and self-efficacy. In addition, regardless of the instructions being adopted, the participants acquired higher motivation and self-efficacy than those of the non-participants. This goes in line with a study by Schukajlow, Leiss, Pekrun, Blum, Müller, & Messner (2012) which revealed that instructions impacted students' motivation and positive attitudes. Particularly, student-oriented forms of teaching and learning had enormous influence on students' attitudes and confidence because

it stimulates students to inspect their own learning which also works to give rise to their perception of abilities. Therefore, teachers should design intriguing and stimulating teaching methods that are innovative and various to attract students' interests to learn, ultimately leading to their perception of abilities and future academic successes.

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