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Full Length Research Paper

An investigation of learning styles influencing mathematics achievement of seventh-grade students

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This study aims to investigate the effect of learning styles, as well as compare the effect of two different variable structure models of learning styles on factors influencing mathematics achievement. The research sample was made up of 508 seventh-grade students. The findings were that the model including learning styles as factors influencing mathematics achievement had a greater coefficient of determination than the one without learning styles; the effect of learning styles treated as exogenous variables had a greater coefficient of determination than learning styles treated as endogenous variables; and the changes in the regression coefficient (b) as well as changes in relations between factors influencing mathematics achievement showed that learning styles was a moderator variable.

Key words: Mathematical achievement, learning styles, attitude toward mathematics, achievement motivation, self-concept, moderator variable.

INTRODUCTION

Mathematics is widely recognized not only as a core component of the curriculum but also as a critical contributor to many educational and career opportunities. Central among the nation's education goals is to improve the quality of mathematics education for all students. (America 2000, 1995). However according to the end of grade mathematics test results, published by the north Carolina state board of education accountability division, the percentage of students achieving acceptable levels of three and four of a maximum level four competency scale successively decrease from grade 3 to grade 8.The implication of this report suggests that there is a need for the improvement in the instructional design of mathematics in the public school system.(White, 2007) to facilitate the students' learning process in order to improve the results. One of the most enduring effects on education had been the search for individual differences that could explain and predict variations in student achievement (Keefe, 1990; Wang et al., 2008; Baljinder et al., 2009). The hope is that pedagogical methods can be designed in a way that will capitalize on different learning styles. A wealth of research has been undertaken with attempts to define and demonstrate the effects of understanding the learning styles of the students will enhance student academic ability through the employment of teaching and learning strategies that are more in tune with their learning preferences. Therefore, it is vital to understand student's individual learning style and provide appropriate instructional methods and learning environments to increase a student's success in academic achievement (Carver et al., 1999; David and Martin, 1994; Bajraktarevic et al., 2003; Brown et al., 2006; Graf and Kinshuk, 2007; Tallmadge and Shearer, 1969).

Concepts of learning styles

Psychology and educational theory had a long tradition of research into learning styles. (Cassidy, 2004). Learning style was a dispositional or trait concept in that it was about how someone usually approaches learning—that was, how they learn. It was not about a state, a specific

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way of learning particular skills or knowledge. Learning style had also been associated with allied terms, like cognitive style and learning strategy. The term cognitive style was used to denote an individual's consistent preferences for particular ways of gathering, processing, and storing information and experiences. It was seen as a fusion of particular methods of thinking and personality (Cuthbert, 2005), whereas learning style was more focused on typical modes in learning situations (Riding and Rayner, 1998). A major difference between these two terms was the number of style elements involved. Specifically, cognitive styles were more related to a bipolar dimension whereas learning styles were not necessarily either/or extremes. Learning strategies were also distinguished from learning styles in referring to strategies that learners select to deal with specific learning activities (Hartley, 1998). The implication was that style was more habitual and automatic, while strategy was more about optional and variable approaches. learning strategy had state qualities, while style had trait qualities.

In a more recent attempt to integrate different conceptions about learning styles, O'Connor (1997) defines personal learning styles in relation to individual characteristics as follows: "*People rely on personally constructed filters to orient their relationships towards the world. These filters each individual has a unique approach to perceive, understand, and plan his/her interactions. (…) Our personal way of selecting can be described as our style*". Another definition is proposed by Dunn and Dunn (1999) as "…*the way in which each individual learner begins to concentrate on, process, absorb, and retain new and difficult information*". Honey and Mumford (1992) define learning as a description of attitudes and, behaviors that influence one's preferred way of learning. Duff and Duffy (2002) definition of learning styles was that they were the composite of cognitive characteristics, affective and psychological factors that influence the way individuals interact and respond to learning environments. They enunciate learning style to be the cognitive characteristics, affective and psychological behaviors that indicate the way learners perceive, interpret and react to learning environments.

To identify students' learning styles, analytical diagnosis were often performed using learning objects: Adaptive retrieval through learning styles size the following kinds of preferences instructional/contextual preferences, information process preferences, preferences of social interaction and personality-related preferences (Curry, 1987). This classificatory schema collaborates in learning processes since they provide information that allows the understanding of the fact that students had distinct ways of learning, but none of them was better or worse than the other. They were simply different (Pollyana and Ismar, 2006). For example learning style theory, with its origins in cognitive psychology, had been particularly influential in management development circles (Duff, 2004). It was most commonly discussed currently in relation to the work of Kolb, whose conception of an experiential learning cycle (Kolb, 1984), and related learning style inventory, provoked many and varied attempts to capture and describe learning styles (Dunn, et al., 1987; Reid, 1987; Honey and Mumford, 1992; Fleming and Bonwell, 1998). A learning style industry had grown up around these ideas offering a variety of commercial inventories, tools and measurement instruments, and policy makers were increasingly taking an interest in these ideas (Coffield et al., 2004). Different definitions of learning styles were made from various perspectives, while the categories of learning style vary, from the activist, reflector, theorist and pragmatist of Honey and Mumford (1992), to the visual, aural, read/write and kinesthetic of VARK (Fleming and Bonwell, 1998) and to Grasha-Reichman who explored child's preferences in thinking and interaction with other children in different classroom environments and experiences to determine student learning preferences in six learning style categories: independent, avoidance, collaborative, dependent, competitive and participant. (Grasha and Reichman, 1975).

In this study, themes and concepts in learning styles of Grasha-Reichman were used because Grasha-Reichman's concept focuses on student attitudes toward learning, classroom activities, teachers, and peers rather than studying the relationships among methods, student style, and achievement. Grasha-Reichman proposed six learning styles including:

(1) Independent (students prefer to work alone and require little direction from the teacher.
(2) Avoidance (students tend to be at the lower end of the grade distribution. They tend to have high absenteeism, they organize their work poorly, and take little responsibility for their learning).
(3) Collaborative (students enjoy working harmoniously with their peers).
(4) Dependent (students typically become frustrated when facing new challenges not directly addressed in the classroom).
(5)Competitive (students are described as suspicious of their peers leading to competition for rewards and recognition).
(6) Participant (students are characterized as willing to accept responsibility for self-learning and relate well to their peers) (Grasha and Reichman, 1975).

Learning styles and academic achievement

Learning is a lifelong process and is a continuous and never ending one. Teacher must assess individual learning style preferences and then adapt their delivery technique to improve the pace of learning according to

learning styles of their students. Learning styles can help students learning more easily and effectively (Prabhakar and Swapna, 2009; Kinshuk et al., 2009). This is because when students understand their strengths and weaknesses, they can learn with greater motivation. The level of learning achieved by a learner is one of the most important factors which indicate the success of a learning environment. Several studies have shown that academic performance of students is related to their learning styles (Rasimah et al., 2008). Irrespective of the instrument used many studies have shown that learning style plays an important role in the academic performance of students. The accommodation of students learning styles in the learning environment have resulted in improved test scores while a mismatch in learning characteristics and learning environment resulted in poor students' achievement. (Andrews, 1990; Dunn et al., 1995; Klavas, 1994).

This is probably accurate as an account of the traditional core of the concept, of learning styles. However, the term has always been used in a wide variety of ways to describe differences in the way people learn. Several other studies found that the existence of a definite relationship between specific aspects of learning styles and measured learning outcomes in terms of academic achievement. Learning style also plays a role in classroom performance. Thus, conclusion from different studies was that as scores in learning styles moves up the scale from dependent to independent so does academic achievement, which are indicators to academic success. (Porter and Cano, 1996; Diaz and Cartnal, 1999; Cano, 1999; Rayneri and Gerber, 2004).

Limitations of previous research on learning styles

There were many definitions of learning styles in the literature. The definitions suggested learning styles as the characteristic ways that individuals collect, organize, and transform information into useful knowledge. The use of learning style was consistent across a wide variety of tasks. It had a broad influence on how information was processed and problems were solved, and it remains stable over many years. (Gregorc and Ward, 1977; Hunt, 1975; Keefe and Languis, 1986). Attempts to discover commonality across many models were rare but the results of those efforts had been made lead to the conclusion that they were not accessing the same constructs. In literature there exist numerous learning styles and learning style models. The differences among definitions and models result from the fact that learning was achieved at different dimensions and that theorists define learning styles by focusing on different aspects.

Several models explaining the effects of learning styles on achievement have emerged throughout the past three decades. Learning styles in those models were treated as endogenous variables (David and Martin, 1994; George and Thomas, 1993; Baljinder et al., 2009; Meryem and Buket, 2009). While many theorists define learning style in term of having a common-sense appeal, an investigation of the field reveals that it is characterized by considerable conceptual confusion and the lack of any generally accepted definition of what these 'styles' may be (Catherine, 2010). They also enunciate learning style to be the cognitive characteristics, affective and psychological behaviors that indicate the way learners perceive, interpret and react to learning environments (Grasha and Reichman, 1975; Kolb, 1984; Keefe and Ferrell, 1990; Dunn and Dunn, 1992; Wintergerst et al., 2001; Peterson et al., 2009; Baykul, 2010), From this point of view, it, should be more appropriate to treat learning styles as exogeneous variables in the structural equation model. This assertion becomes even more important as educators and researchers consider order learning styles differences. If 'learning style' changes the relation between other variables (a predictor) and an outcome (mathematics achievement) that means 'learning style' was moderator variable.

The research conceptual framework was developed from education paradigms, learning style theories and research about factors affecting academic achievement (George and Thomas, 1993; David and Martin, 1994; Vittorioet et al., 1999; Baljinder et al., 2009; Meryem and Buket, 2009). This research focuses on the effect of learning styles on students' Mathematics achievement in different constructs of design models "how much coefficient of determination and parameter estimate in the model were different between comparing the model including with Learning Style and within Learning Style?" The first model did not include learning style for SEM but include 3 latent variables; namely attitude toward mathematics; achievement motivation and self-concept investigate the effect of 3 latent variables on mathematics achievement. The second model used learning style as endogenous variables in the structural equation modeling (SEM) along with 3 latent variables (attitude toward mathematics, achievement motivation and self-concept) the result would show how the coefficient of determination had changed when using the learning style as endogenous variables in the structural equation model. The third model used learning style as exogenous variables along with 3 latent variables(attitude toward mathematics, achievement motivation and self-concept) the result would show how the coefficient of determination had changed when using the learning style as exogenous variables in the structural equation model. Each hypothetical model had different latent variables and observed variables depending on the research questions. Variables are presented in Table 1.

METHODOLOGY

Samples

The research samples were 508 seventh-grade students in 25 public schools under the office of Nakhonrachasima Educational

Table 1. A design variables in Model.

Model	Variables									Note
	ATM	MOT	SEL	LS1	LS2	LS3	LS4	LS5	LS6	
1	✓	✓	✓	-	-	-	-	-	-	-
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	Learning style as endogenous variables
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	Learning style as exogenous variables

ATM=Attitude toward mathematics; MOT= Achievement motivation; SEL= Self-concept; LS1= Independent; LS2= Avoidance; LS3= Collaborative; LS4 = Dependent; LS5= Competitive; LS6 = Participant.

Table 2. The research samples.

Section	Number of School	Gender				Total
		Boys		Girls		
		f	%	f	%	
Seventh grade in primary school	9	94	18.50	83	16.34	177
Seventh grade in secondary school	16	138	27.16	193	37.99	331
Total	25	232	45.66	276	54.33	508

Table 3. The psychometric properties of the questionnaires used in this research.

Variable	Item	IOC	r_{xy}	$\overline{X_{r_{xy}}}$	α
Learning styles	60	0.66 -1.00	0.401-0.819	0.578	0.969
Attitude toward mathematics	15	0.66 -1.00	0.423 -0.749	0.605	0.908
Achievement motivation	15	0.66 -1.00	0.401 -0.798	0.617	0.912
Self-concept	15	0.66 -1.00	0.487 -0.743	0.614	0.911

Service Area of Thailand. The research samples were obtained from three stage random samplings. The sampling of each stage was province number of schools, and classes, respectively. A description of the sample is presented in Table 2.

Instruments

The student's self descriptive questionnaire is a 45 Item rating scale designed to assess the students' attitude toward mathematics (15 items) achievement motivation (15 items) and self-concept (15 items). The researcher developed to measure and to record perception, personal data. Reliability of attitude toward mathematics, achievement motivation, and self-concept were 0.97, 0.91, and 0.91 respectively.

The student learning styles scale (SLSS : Grasha and Reichman, 1975) the SLSS comprised of 60 items assessing learning styles were translated into Thai from "the student learning styles scale" (SLSS) of Grasha and Reichman (1975). Reliability with Cronbach's alpha coefficients for SLSS as 0.91

Student achievement tests in mathematics consisted of 30 multiple choices questions, means of item difficulty were ranged between 0.37 and 0.80, means of item discrimination ranged from 0.35 to 0.90, and reliability of the test was 0.94 psychometric properties of the scales used in this study are presented in Table 3 and 4.

Data collection and data analysis

The research data was collected from students using a set of questionnaires (including learning style, attitude toward mathematics, achievement motivation and self-concept and the mathematics achievement tests. The research data was employed descriptive statistics and employed the exploratory factor analysis (EFA) to explore observe variables of six learning style models and the employed structural equation model (SEM) to develop and validity the hypothesized models by using Mplus program version 6.11. For answer the purposes 1 "to investigate theeffect of learning styles on factors influencing mathematics achievement" the research design model did not include learning style in the structural equation model (SEM) but used 3 latent variables: Attitude toward mathematics, achievement motivation and self-concept for the structural equation model (Model 1). For the answer to the purposes 2 "to compare the effect of two different variable structures models of learning styles on factors influencing mathematics achievement" the research design 2 model: Model 2 used learning style as endogenous variables in the structural equation model with 3 latent variables (attitude toward mathematics, achievement motivation and self-concept) and Model 3 used learning style as exogenous variables in the structural equation model with 3 latent variables (attitude toward mathematics, achievement motivation and self-concept).

Exploratory factor analysis was used to determine the number of underlying dimensions contained in a set of observed variables for each learning styles for analysis by the structural equation model (SEM) with Mplus program version 6.11. One of the advantages to SEM, is that latent variables are free of random error. This is because error has been estimated and removed, leaving only a common variance.

Table 4. The psychometric properties of the mathematics achievement tests.

Variable	Item	IOC	p	r	KR.20
Mathematics achievement	30	0.66 - 1.00	0.37 - 0.80 ($\overline{X}$ p=0.671)	0.35 - 0.90 ($\overline{X}$ r=0.659)	0.944

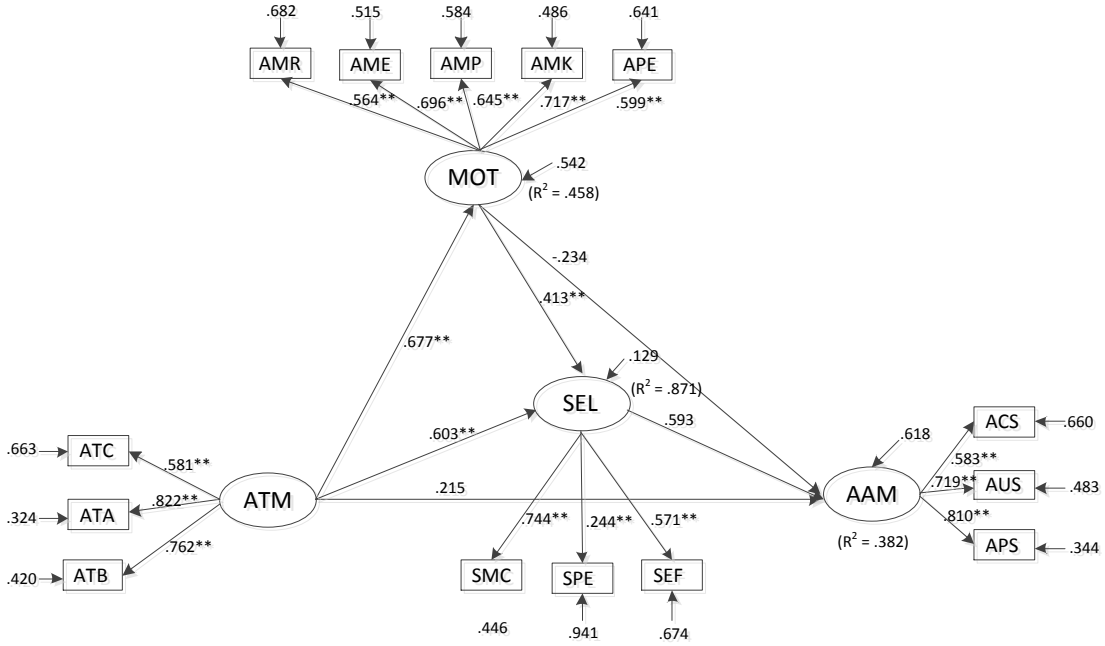

Figure 1. Model of factor affecting mathematics achievement without learning style factor model 1. 53.787, df= 51, p-value= 0.3681, CFI=0.999, TLI=0.998, RMSEA=0.010, SRMR = 0.023, R^2= 0.382.

RESULTS AND DISCUSSION

The result of SEM of the three research hypothetical models showed the first model was the best fit with the empirical data with the chi-square 53.787, R^2 =0.382 .The second model was the best fit with the empirical data with the chi-square 190.630, R^2 =0.334. The third model was the best fit with the empirical data with the chi-square 190.630, R^2=0.472. The models of each research hypothetical model are shown in Figure 1 to 3 below. The goodness of fit indices for each of the research hypothetical models are shown in Table 5.

The result from model comparison shows the different coefficient of determination model 1 did not include learning style variable in the structural equation model but used 3 latent variables. The coefficient of determination of model 1 was 0.382, when the learning styles were treated as endogenous variables in structural equation model along with 3 latent variables (Model 2) the coefficient of determination changed to 0.334, and when the learning styles were treated as exogeneous variables in structural equation model was used along with 3 latent variables (Model 3) the coefficient of determination changed to 0.472.

The result of the different learning styles models affecting mathematics achievement shows different results for the coefficient of determination. When the learning style variable for structural equation model (SEM) was not included, the coefficient of determination was lower than when learning style variable for structural equation model (SEM) was included. This strongly supported the assumption that learning styles affect academic achievement (Charkins, and O'Toole, 1985, Hawk and Shaw, 2007; Terregrossa et al., 2009; Charkins et al., 1985; Brokaw and Merz, 2000). In addition,the order of learning style for structural equation modelling (SEM)'s coefficient of determination had changed 0.138 similar to model 3 using learning style as exogenous variables in SEM had a coefficient of determination more than model 2 that used learning style as endogenous variables in structural equation modeling, which strongly supported learning styles as having relatively consistent preferences for adopting learning processes, irrespective of the task or problem presented

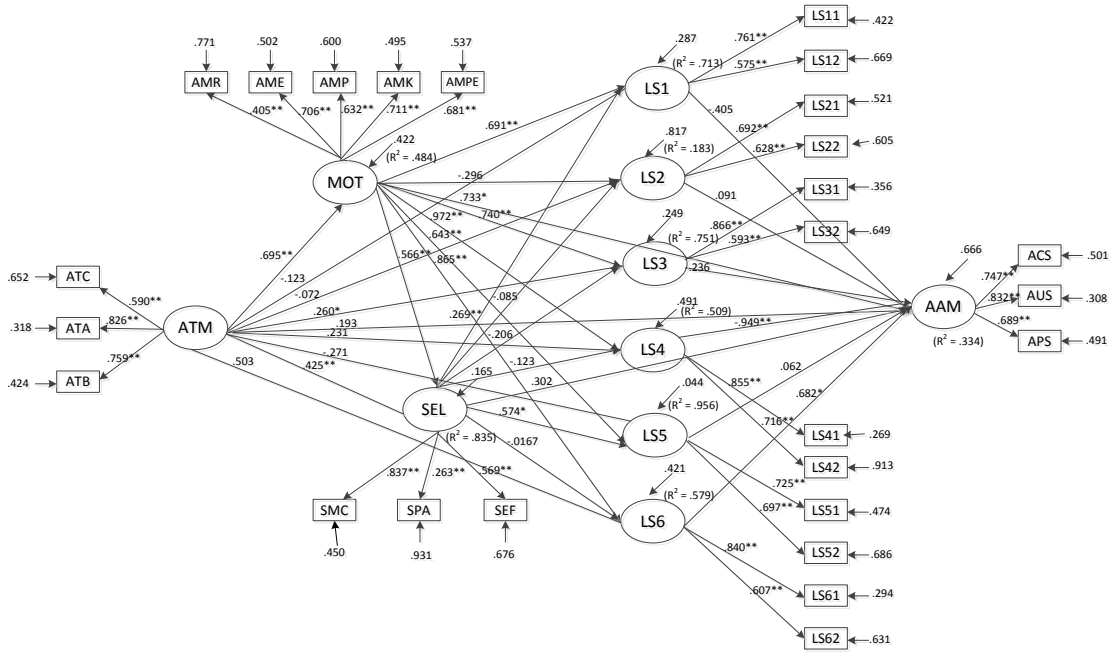

Figure 2. Model of factor affecting mathematics achievement with learning style as endogenous variables model 2. 190.630, df= 188, p-value= 0.4328, CFI=1.000, TLI=0.999, RMSEA=0.005, SRMR = 0.028, R^2= 0.334

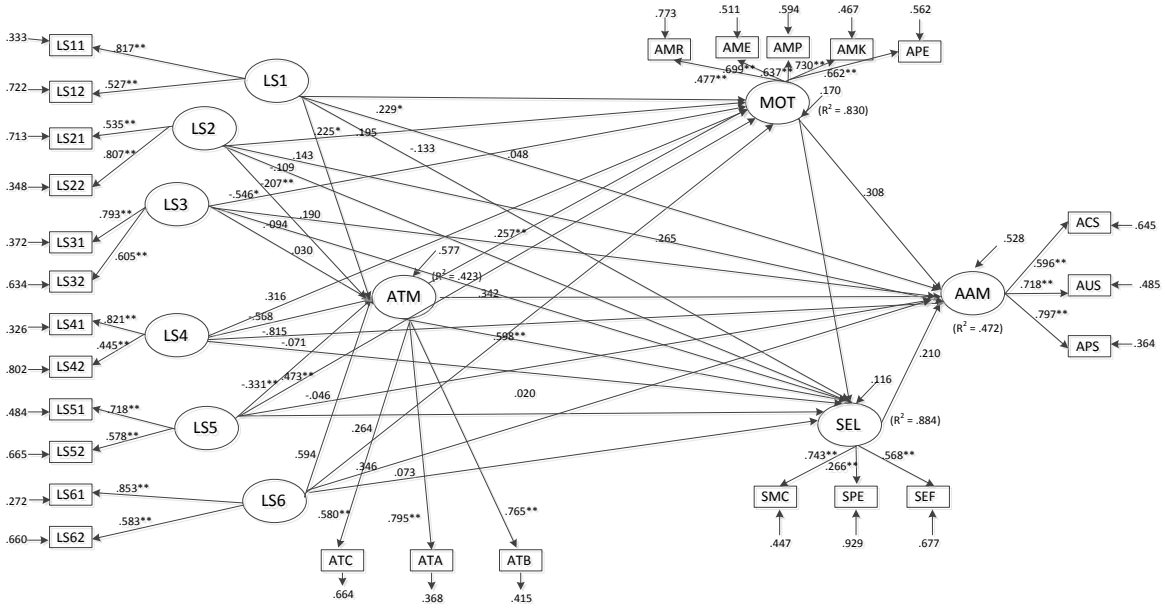

Figure 3. Model of factor affecting mathematics achievement with learning style as exogenous variables model 3. 190.589, df = 188, p-value= 0.4336, CFI= 1.000, TLI= 0.999, RMSEA= 0.005, SRMR = 0.031, R^2=.472

and Learning styles regarded as being relatively malleable or relatively stable (Entwistle and Peterson, 2004; Peterson et al., 2009). Though all human beings have common bio-psychological and social characteristics in learning processes, individual preferences concerning the ways of giving meaning and acquiring information may vary. Even identical twins who share the same environment may give meaning in different ways the phenomena and events which have common characteristics. Consequently, educational interventions would not be effective in changing students' approaches to studying unless they also serve to bring

Table 5. The goodness of fit indices of three research hypothetical models**.**

Descriptive statistics	Model 1	Model 2	Model 3
	Factor affecting mathematics achievement without learning style	Factor affecting mathematics achievement with learning styleas endogenous variables	Factor affecting mathematics achievement with learning style as exogenous variables
Chi-Square	53.787	190.630	190.589
Degrees of freedom	51	188	188
x^2/df	1.054	1.013	1.013
p-value	0.3681	0.4328	0.4336
CFI	0.999	1.000	1.000
TLI	0.998	0.999	0.999
RMSEA	0.010	0.005	0.005
SRMR	0.023	0.028	0.031
R^2	0.382	0.334	0.472

about changes in the students' perceptions (John, 2010). The result indicated that achievement motivation affecting mathematics achievement in model 1 regression coefficient (b) was negative b = -0.234 but when used learning style as endogenous variables or exogenous variables in structural equation model (Models 1 and 2), achievement motivation had change, regression coefficient (b) was positive in model 1: b = 0.733 and in model 2, b = 0.308. This finding supported the view that learning styles should be moderator variables because learning styles had the causal effect of achievement motivation on depression of mathematics achievement.

RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

The findings help in getting a deeper understanding about how learning styles affecting mathematic achievement. Further research into the model of learning styles affecting to academic achievement with other subject's achievement and other factors would lead to a deeper understanding about learning styles as moderator variables or mediator variables.

School administrators and teachers should plan activities for learning and education for students that fit their learning styles or give them hints about how to learn using their preferred learning styles to increase academic achievement, and therefore, work to identify these styles when students seem to have difficulties in learning and providing them with suggestions on how to overcome the struggles.

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