THE MEASUREMENT OF A MULTIDIMENSIONAL LEARNING STRATEGY IN UPPER SECONDARY SCHOOL STUDENTS: COMPETING MODEL, AND PREDICTING ON ACADEMIC ACHIEVEMENT

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Abstract: The purposes of this study were 1) to compare the efficiency of learning strategies measurement models consisted of (a) Weinstein and Palmer's Model, (b) Stevens and Tallent-Runnels's Model, (c) Cano's Model, and (d) Model developed by the researcher, and 2) to assess the prediction of measurement efficiency of students' learning strategies on academic achievement. The participants were 2,187 upper secondary school students from schools under the jurisdiction of the Office of the Basic Education Commission of Thailand. The instrument for data collection was a multidimensional learning strategies scale for upper secondary school students. In the results of this study, the model developed by the researcher was the most efficient model consisted of three dimensions: cognitive, affective, and skill strategies. This model was identified by χ^2=24.666 (df =17, p=.102), χ^2/df=1.451, GFI=.998, AGFI=.993, RMR=.008, RMSEA=.014, CFI=1.000, and AIC=100.666 (Saturated AIC=110.000). The skill strategy, affective strategy, and cognitive strategy had significant positive effects on academic achievement. The standardized regression coefficients were .274, .241, and .227, respectively. Each strategy accounted for 7.50, 5.80, and 5.10 percents of variance in the academic achievement. There was low error of prediction for .008, .007, and .010, respectively.

Introduction

For many years, Thai education has been reformed, especially in the areas of teaching and learning management, curriculum, educational administration, and educational structure. Although some educational reform has taken place, quality of education is still unsatisfactory. Educational reform has not caused an improvement in the ability of Thai students. Moreover, several studies reflect the quality of Thai education. For instance, the survey of Organization Economic Co-operation and Development (OECD) found that science knowledge among 47% of Thai students was lower than standard. United Nations Educational, Scientific and Cultural Organization (UNESCO) said that Thailand should improve the quality of all levels of education, from primary education through higher education (Chareonwongsak, 2008). In 2005, the results evaluated by the Office for National Education Standards and Quality Assessment (ONESQA) revealed that academic achievement at the primary education level was below 50% of national standards in all subjects (ONESQA, 2007). In addition, according to the world competitiveness ranking by the Institute of Management Development (IMD), Thailand's education in 2006 ranked 48th out of 61 countries, in 2007 46th out of 55 countries, and in 2008 43rd out of 55 countries (Office of the Higher Education Commission, 2008). According to all reports of OECD, UNESCO, ONESQA, and IMD, they reflect the current quality of education in Thailand. Furthermore, according to these reports, academic achievement and learners' educational quality are not only dependent upon learner's aptitude, but they are also influenced by several other factors as well. According to Lindgren (1969), students' academic success was based on learning and study strategies (33%), learning attention (25%), aptitude (15%), and other factors (27%). For students who failed, there were factors such as lack of attention to learning (35%), poor learning performance (25%), and personal problems and other factors (40%). The research of Keng (1996) was related to Lindgren's idea and revealed that students' learning strategies are able to improve students' understanding and academic achievement. The strategies were record, study planning, learning review, and preparing for examination.

A learning strategy is a method which a person uses for his or her learning. Students can acquire learning strategies through practice or they can perform them spontaneously performance (Riding & Rayner, 1998). Evaluating learning strategies is useful to develop learning, to investigate strengths and weaknesses regarding the methods and learning techniques of students, and to assess learners' capacity. The assessment increases learning attention of the learners (Prevatt & et al, 2006; Weinstein & Palmer, 2002). Therefore, learning strategy is an essential theory for the development of educational quality.

Research studies on learning strategy scales (e.g. Pintrich & others, 1991; Murphy & Alexander, 1998; Chamot & et al, 1999; Weinstein & Palmer, 2002; Arias & Justicia, 2003; Stevens & Tallent-Runnels, 2004; Cano, 2006) indicate that learning strategies are multidimensional, complex, and can be discussed in many aspects. For this reason, research results on learning strategies are oftentimes relatively unclear and ambiguous, possibly due to the inconsistency of measurement. Moreover, learning strategies can reflect learning weaknesses (Wittrock, 1986) and are a good prediction of

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students' academic performance (Weinstein & Palmer, 2002; Prevatt & others, 2006). Because of the above problems, it is important to compare multidimensional learning strategy models and evaluate prediction of learning strategies on academic achievement.

Purposes of this study

The purposes of this study were 1) to compare the efficiency of learning strategies measurement models consisted of (a) Weinstein and Palmer's Model, (b) Stevens and Tallent-Runnels's Model, (c) Cano's Model, and (d) Model developed by the researcher, and 2) to assess the prediction of measurement efficiency of students' learning strategies on academic achievement.

Methods

Participants

Participants of this study were 2,187 upper secondary school students composed of 1,342 females and 845 males. For educational level, participants were grade 10 (780 students), grade 11 (738 students), and grade 12 (669 students).

Instrument

The Multidimensional Learning Strategies Scale (MLSS) was a within-item multidimensional instrument with 44 items. The items were selected through a process of tool development, and each item was measured on a four-level rating scale ranging from 1 (rarely) to 4 (frequently).

The investigator developed the MLSS from two principals. The first principal is relevance to definition of learning. In literature reviews, learning refers to behavior change, especially cognitive, affective, and psychomotor domains (The Royal Institute, 2005). The investigator used this definition of learning to develop the MLSS. The secondary principal is an indicator development for learning strategies. Indicators of MLSS were based on indicators of learning and study strategies (LSS) of Weinstein and Palmer (2002). Their ordinary indicators were comprised of information processing, selecting main ideas, test strategies, anxiety, attitude, motivation, concentration, self-testing, study aids, and time management. The indicators of Weinstein and Palmer were appropriate for developing indicators of this study because the definitions of "learning" and "study" in Thai and English dictionary are synonyms, and they have the same meaning (Thiengburanathum, 1996, p. 920; Collins & Hands, 2002, p. 587; Waite, Hollingworth & Marshall, 2006, p. 484). In specific definitions, "learning strategies" and "study strategies" are interchangeable. In addition, study strategy is a factor of learning strategy (Stroud & Reynolds, 2006). The anxiety indicator of LSS was modified to be the anxiety management indicator in this study.

Based on the definition of learning and on the indicator development, this study generated a model of multidimensional learning strategies with three factors: cognitive, affective, and skill strategies.

1. Cognitive strategies had three indicators: information processing, self-testing, and time management.
2. Affective strategies had four indicators: attitude, motivation, concentration, and anxiety management.
3. Skill strategies had three indicators: selecting main ideas, test strategies, and study aids.

The instrument was tested with 617 upper secondary school students. Following this administration, EAP reliability was analyzed by ConQuest 2.0 in order to estimate the value of marginal maximum-likelihood (MML). The EAP reliability values of cognitive strategy, affective strategy, skill strategy were .849, .878, and .844, respectively. In addition, The Cronbach's alpha-coefficient values were .821 (SEM = 2.690), .824 (SEM = 2.885), and .832 (SEM = 2.619), respectively.

Construct validity was supported by two methods: multidimensional analysis and confirmatory factor analysis. The multidimensional analysis was based on multidimensional model known as the Multidimensional Random Coefficients Multinomial Logit Model (MRCMLM; Adams, Wilson & Wang, 1997). The investigator used ConQuest 2.0 to analyze multidimensional forms of the partial credit model for this analysis. Learning strategies model of the multidimensional approach was a better fitting model than the composite approach (Deviance Statistic (G^2) of Multidimensional approach=56,461.589, Composite approach = 56,527.426) and the consecutive approach (Akaike Information Criterion (AIC) of Multidimensional approach=56,737.589, Consecutive approach= 63,750.977). Furthermore, Unweighted Mean Square (OUTFIT MNSQ) values of total items ranged from .860 to 1.320, and values of weighted Mean Square (INFIT MNSQ) were from .870 to 1.300. The acceptable values of OUTFIT MNSQ and INFIT MNSQ are ranged from .60 to 1.40 (Wright & et al., 1994). The confirmatory factor analysis used LISREL 8.72 to analyze the construct validity. The model of the Multidimensional Learning Strategies was fit to empirical data. The value of chi-square was 758.582 (df=705, p=.079). In addition, fit statistics indicated a good model fit as follows: the Goodness of Fit Index (GFI=.998), the Adjusted Goodness of Fit Index (AGFI=.993), the Root Mean Square Residual (RMR=.008), and the Root Mean Square Error of Approximation (RMSEA = .014).

Results

1. Correlation coefficient matrix and descriptive statistics for indicators of learning strategies, academic achievement

Pearson's Correlation Coefficient was used to analyze the indicators of learning strategies presented in Table 1. The correlation within 45 pairs of indicators ranged from .375 to .733. The relationship of each pair was at a moderate to high level. Time management (TMT) and test strategies (TST) had the highest positive correlation (r=.733, p=.05). On the other hand, the relationship between information processing (INP) and anxiety management (AMT) was the

lowest (r=.375, p=.05). The correlation within 10 pairs between indicator of learning strategies and academic achievement ranged from .100 to .262. Test strategies (TST) and academic achievement (GPA) had the highest positive correlation (r=.262, p=.05). Whereas, the relationship between self-testing (SFT) and academic achievement (GPA) was the lowest (r=.100, p=.05).

(2) Work ethic had five indicators: motivation, time management, concentration, attitude, and selecting main ideas.

(3) Test-taking approach had three indicators: test strategies, anxiety, and selecting main ideas.

3) Cano's Model (C) had three factors:

(1) Comprehension monitoring strategies had four

Table 1: Correlation Coefficient Matrix and Descriptive Statistics for Indicators of Learning Strategies (n = 2,187)

Indicator	GPA	INP	SFT	TMT	ATT	MOT	CON	AMT	SMI	TST	STA
GPA	1.000										
INP	.104*	1.000									
SFT	.100*	.560*	1.000								
TMT	.208*	.527*	.626*	1.000							
ATT	.155*	.450*	.534*	.549*	1.000						
MOT	.154*	.408*	.580*	.559*	.600*	1.000					
CON	.184*	.427*	.532*	.551*	.608*	.534*	1.000				
AMT	.202*	.375*	.377*	.504*	.490*	.478*	.466*	1.000			
SMI	.172*	.509*	.556*	.616*	.522*	.564*	.535*	.503*	1.000		
TST	.262*	.424*	.474*	.733*	.485*	.501*	.496*	.599*	.569*	1.000	
STA	.258*	.515*	.517*	.583*	.491*	.518*	.462*	.487*	.648*	590*	1.000
Mean	2.819	9.560	12.210	18.720	11.610	14.200	10.740	13.830	13.110	14.440	13.790
SD	.591	1.997	2.647	3.604	2.129	2.863	2.224	2.603	2.636	2.910	2.683

Bartlett's Test of Sphericity = 12416.840 p < .000
Kaiser–Meyer–Olkin Measure of Sampling Adequacy (KMO) = .926

Note: INP=information processing; SFT=self-testing; TMT=time management; ATT=attitude; MOT=motivation; CON=concentration; AMT=anxiety management; SMI=selecting main ideas; TST=test strategies; STA=study aids.
*P < .05.

Once Bartlett's Test of Sphericity tested the relationship within dependent variables, the value of Bartlett's test was 12416.840 (p < .000). This revealed that the correlation matrix between indicators was significantly different from the identity matrix. Furthermore, factor analysis and multivariate analysis are suitable to analyze the data of this study because intercorrelation within dependent variables was highly appropriate. The value of Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) was .926. The value is higher than an acceptable value .500 and upper (Hair & et al, 2006).

2. Competing model of learning strategies

Four learning strategy models for comparing model were as follows:

1) Weinstein and Palmer's Model (A) had three factors:

(1)Self-regulation had four indicators: concentration, self-testing, study aids, and time management.

(2) Will have three indicators: anxiety, attitude, and motivation.

(3) Skill had three indicators: information processing, selecting main ideas, and test strategies

2) Stevens and Tallent-Runnels's Model (B) had three factors:

(1)Cognitive strategies had four indicators: information processing, study aids, self-testing, and selecting main ideas.

indicators: selecting main ideas, information processing, self-testing, and study aids.

(2) Affective strategies had four indicators: time management, motivation, concentration, and attitude.

(3) Goal strategies had five indicators: concentration, attitude, anxiety, test strategies, and selecting main ideas.

4) Model developed by the researcher (D) had three factors:

(1) Cognitive strategies had three indicators: information processing, self-testing, and time management.

(2) Affective strategies had four indicators: attitude, motivation, concentration, and anxiety management.

(3) Skill strategies had three indicators: selecting main ideas, test strategies, and study aids.

Table 2 shows that the overall learning strategy models were analyzed second-order confirmatory factor analysis. Overall model fit to empirical data and not significant between model. The model developed by the researcher (D) was the most efficient model. This model was identified by Chi-square (χ^2)=24.666 (df=17, p=.102), The relative chi-square (χ^2/df)=1.451, Goodness of Fit Index (GFI)=.998, Adjusted Goodness of Fit Index (AGFI)=.993, Root Mean Square Residual (RMR)=.008, Root Mean Square Error of Approximation (RMSEA)=.014, Comparative Fit Index (CFI)=1.000, and Akaike Information Criterion (AIC)=100.666 (Saturated

AIC=110.000). Result of analysis overall model shows Figure 1-4.

Table 2: Result of Analysis of Comparing Efficient Model

Model	Indices									
	χ^2	df	p	χ^2/df	GFI	AGFI	RMR	RMSEA	CFI	AIC (Saturated AIC= 110)
A	25.968	16	.055	1.623	.998	.992	.007	.017	1.000	103.968
B	24.845	16	.073	1.553	.998	.992	.008	.016	1.000	102.845
C	23.877	16	.092	1.492	.998	.993	.007	.015	1.000	101.877
D	24.666	17	.102	1.451	.998	.993	.008	.014	1.000	100.666

$\Delta\chi^2_{A-B} = 1.123$ $\Delta df_{A-B} = 0$
$\Delta\chi^2_{A-C} = 2.091$ $\Delta df_{A-C} = 0$
$\Delta\chi^2_{A-D} = 1.302$ $\Delta df_{A-D} = 1$
$\Delta\chi^2_{B-C} = .968$ $\Delta df_{B-C} = 0$
$\Delta\chi^2_{B-D} = .179$ $\Delta d_{B-D} = 1$
$\Delta\chi^2_{C-D} = .789$ $\Delta df_{C-D} = 1$

Note: A= Weinstein and Palmer's Model; B= Stevens and Tallent-Runnels's Model; C= Cano's Model; Model developed by the researcher; χ^2= Chi-square; df=Degree of Freedom; p=p-value; χ^2/df ;relative chi-square; GFI=Goodness of Fit Index; AGFI= Adjusted Goodness of Fit Index; RMR= Root Mean Square Residual; RMSEA= Root Mean Square Error of Approximation; CFI= Comparative Fit Index; AIC= Akaike Information Criterion; $\Delta\chi^2_{i-j}$=Difference of Chi-square between i and j; Δdf_{i-j}= Difference of Degree of freedom between i and j.

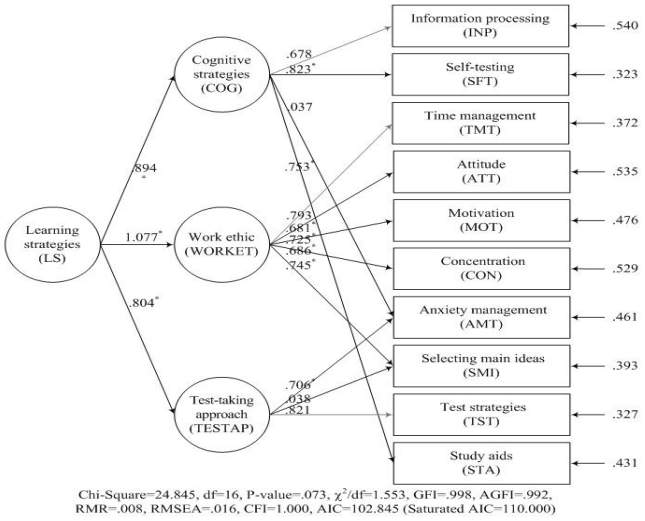


Figure 1: Weinstein and Palmer's Learning Strategy Model

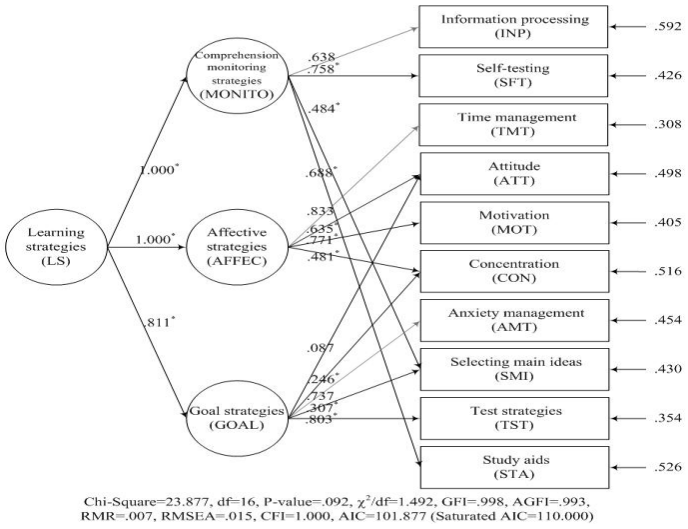


Figure 2: Stevens and Tallent-Runnels's Learning Strategy Model

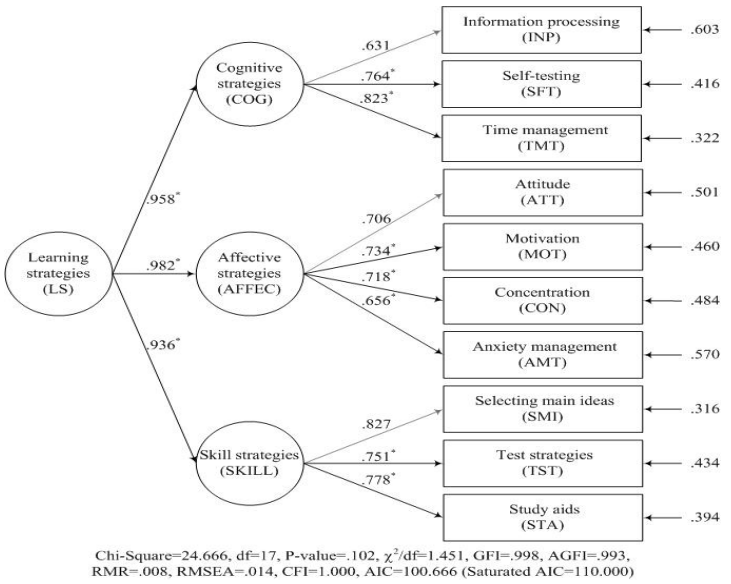


Figure 3: Cano's Learning Strategy Model

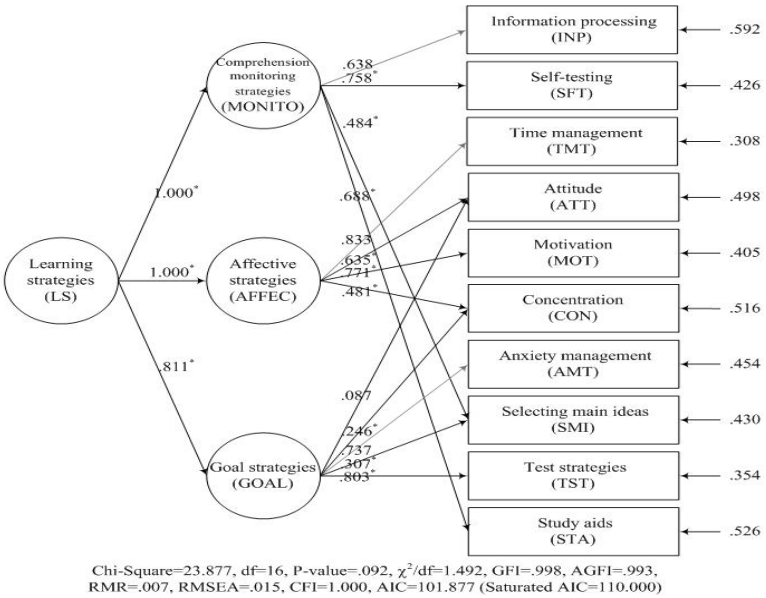


Figure 4: Model of Learning Strategy Developed by the Researcher

3. The prediction of measurement efficiency of students' learning strategies on academic achievement

An analysis of the prediction of the measurement efficiency of students' learning strategies on academic achievement was done using LISREL 8.72. The multidimensional learning strategies model developed by the researcher (The most efficient model from competing model) consisted of three factors: cognitive strategy, affective strategy, and skill strategy was predicted on academic achievement presented in Table 3. Cognitive strategy consisted of three indicators: time management, information processing, and self-testing had factor loadings .889, .591, and .470, respectively. The variance proportions of indicators in each factor were account for at high or highest level. The square multiple correlations (R^2) were 79.00%, 34.90% and 22.10%, respectively. The predictive model of cognitive strategy on academic achievement was fit to the empirical data indicated by Chi-square (χ^2) =3.679 (df=1, p=.055), Goodness of Fit Index (GFI) =.999, Adjusted Goodness of Fit Index (AGFI) =.992, and Root Mean Square Error of Approximation (RMSEA) =.035. In addition, the cognitive strategy had significant positive effects on academic achievement. The standardized regression coefficient was 227. This strategy

accounted for 5.10 percent of variance in the academic achievement, and this model had low error of prediction (Root Mean Square Residual; RMR=. 010) (Figure 5).

Affective strategy consisted of four indicators: concentration, anxiety management, attitude, and motivation had factor loadings .829, .754, .652, and .640, respectively. The variance proportions of indicators in each factor were account for at high or highest level. The square multiple correlations (R^2) were 68.70%, 56.90%, 42.50%, and 41.00%, respectively. The predictive model of affective strategy on academic achievement was fit to the empirical data indicated by Chi-square (χ^2) =3.067 (df=2, p=.216), Goodness of Fit Index (GFI) =.999, Adjusted Goodness of Fit Index (AGFI) =.996, and Root Mean Square Error of Approximation (RMSEA) =.016. In addition, the affective strategy had significant positive effects on academic achievement. The standardized regression coefficient was 241. This strategy accounted for 5.80 percent of variance in the academic achievement, and this model had low error of prediction (Root Mean Square Residual; RMR=. 007) (Figure 6).

Skill strategy consisted of three indicators: study aids, test strategies, and selecting main ideas had factor loadings .990, .884, and .651, respectively. The variance proportions of indicators in each factor were account for at high or highest level. The square multiple correlations (R^2) were 98.00%, 78.10%, and 42.40%, respectively. The predictive model of skill strategy on academic achievement was fit to the empirical data indicated by Chi-square (χ^2)=3.812 (df=2, p=.149), Goodness of Fit Index (GFI) =.999, Adjusted Goodness of Fit Index (AGFI) =.996, and Root Mean Square Error of Approximation (RMSEA) =.020. In addition, the skill strategy had significant positive effects on academic achievement. The standardized regression coefficient was 274. This strategy accounted for 7.50 percent of variance in the academic achievement, and this model had low error of prediction (Root Mean Square Residual; RMR=. 008) (Figure 7).

Table 3: Result of the Prediction of Learning Strategies on Academic Achievement

Factor/ Indicator/ Variable	Factor loading	Regression coefficient	Standard error	t	Factor loading (completely standard solution)	Standardized regression coefficient	Square multiple correlation (R^2)
COG		.227*	.023	9.691		.227	
INP	.591*		.021	27.512	.591		.349
SFT	.470*		.071	6.585	.470		.221
TMT	.889*		.017	52.250	.889		.790
GPA	1.000				1.000		1.000
χ^2 = 3.679 (df = 1, p = .055) GFI = .999 AGFI = .992 RMR = .010 RMSEA = .035 R^2 =.051							
AFFEC		.241*	.024	10.084		.241	
ATT	.652*		.036	18.224	.652		.425
MOT	.640*		.034	18.787	.640		.410
CON	.829*		.042	19.621	.829		.687
AMT	.754*		.039	19.159	.754		.569
GPA	1.000				1.000		1.000
χ^2 = 3.067 (df = 2, p = .216) GFI = .999 AGFI = .996 RMR = .007 RMSEA = .016 R^2 =.058							
SKILL		.274*	.020	13.740		.274	
SMI	.651*		.019	34.193	.651		.424
TST	.884*		.026	33.900	.884		.781
STA	.990*		.015	64.799	.990		.980
GPA	1.000				1.000		1.000
χ^2 = 3.812 (df = 2, p = .149) GFI = .999 AGFI = .996 RMR = .008 RMSEA = .020 R^2 =.075							

Note: χ^2= Chi-square; df=Degree of Freedom; p=p-value; GFI=Goodness of Fit Index; AGFI= Adjusted Goodness of Fit Index; RMR= Root Mean Square Residual; RMSEA= Root Mean Square Error of Approximation; R^2=Square multiple correlation.
*p < .05

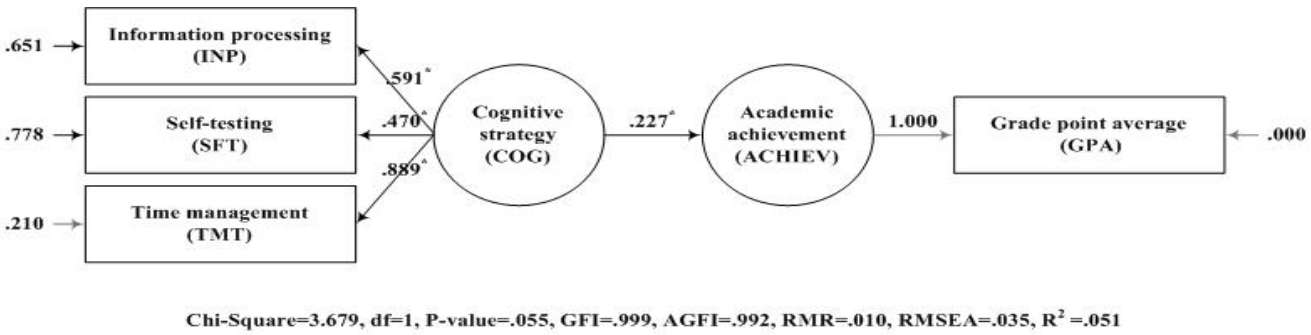
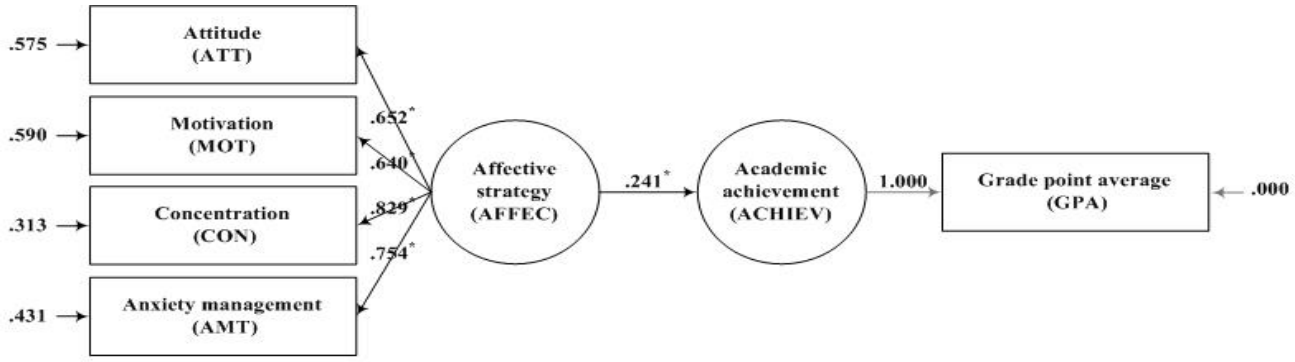
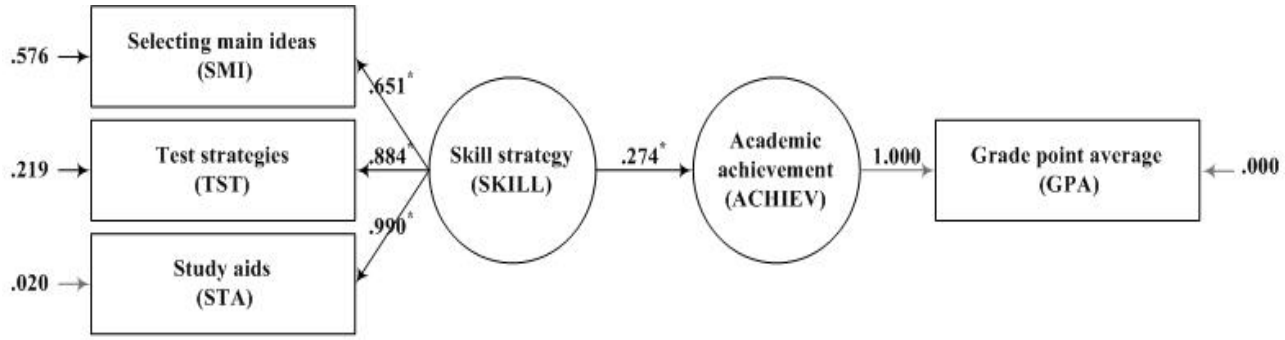


Figure 5: **Result of the Prediction of Cognitive Strategy on Academic Achievement**



Chi-Square=3.067, df=2, P-value=.216, GFI=.999, AGFI=.996, RMR=.007, RMSEA=.016, R^2 =.058

Figure 6: Result of the Prediction of Affective Strategy on Academic Achievement



Chi-Square=3.812, df=2, P-value=.149, GFI=.999, AGFI=.996, RMR=.008, RMSEA=.020 R^2 =.075

Figure 7: Result of the Prediction of Skill Strategy on Academic Achievement

Discussion

It has been evidenced that the model developed by researcher is the most efficient model consisted of three factors, corresponding to the logic of Weinstein and Palmer (2002) which states that the indicator of learning strategies comprise information processing, self-testing, time management, attitude, motivation, concentration, anxiety management, selecting main ideas, test strategies, and study aids have cover learning strategies structure. In the same vein, Hair et al. (2006) state that indicators for scale development have been upper two indicators. In addition, model developed by researcher has clear indicator in each factor. Also, the model is related to meaning of learning and culture of Thailand. Learning can be defined as the relatively permanent behavior changes in the cognitive domain, affective domain, and psychomotor domain, caused by training, setting conditions, or imitation. These changes do not include those stimulated by maturity, instinct, narcotic drugs, accidents, or fatigue (The Royal Institute, 2005).

The cognitive, affective, and skill strategies had significant positive effects on academic achievement and three models are fit to empirical data, corresponding to the conclusion for the learning strategies by Wittrock (1986). According to the researchers, can also be used as a stimulus for students to think and learn by themselves which, in turn, can lead to self-control and management toward goals, thus creating more determination, motivation, understanding, and learning. In addition, learning strategies can reflect learning weaknesses. Moreover, learning strategies are a good prediction of students' academic performance (Weinstein & Palmer, 2002; Prevatt & others, 2006).

Recommendation

The development learning strategies for high academic achievement in this study will be developed in order of magnitude standardized regression coefficient as follows: skill strategy, affective strategy, and cognitive strategy, respectively. In addition, participator will be developed cover behavioral (e.g. time management, concentration, and study aids) for students by intervene in subject.

For future research, as learning strategies are known to relate with academic achievement, also beneficial will be prediction based on item response model, and research and development on how multidimensional learning strategies, consisting of cognitive, affective, and skill strategies can lead to academic achievement. Moreover, the future research should examine the invariance of the prediction multidimensional learning strategies model on academic

achievement in various groups (e.g. Gender, Area, and Under the Jurisdiction).

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