

RESEARCH SYNTHESIS AND STRUCTURAL EQUATION MODEL VALIDATION OF CRITICAL THINKING

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Abstract: The purposes of this research were: 1) to synthesize the body of knowledge resulting from critical thinking research, 2) to develop and validate the critical thinking model, and 3) to develop and validate the causal model with factors affecting critical thinking. The 86 master's theses, doctoral dissertations, and research reports related to critical thinking were subjects of this study. The undergraduate student samples for structural equation model validation consisted of 1,872-second year undergraduate students, selected through multi-stage random sampling from 90 classrooms in the 5 faculties and 7 fields of 3 Rajabhat Universities in Bangkok area. Questionnaires, tests, research quality evaluative form, and research characteristic coding form were employed for data collection. Meta-Analysis, content analysis, confirmatory factor analysis, and structural equation model were employed for data analysis using SPSS, and LISREL programs. The results were as follows: (1) the results from meta-analysis indicated that factor affecting critical thinking were teaching method factors, student factors, and teacher factors, (2) student-level variables consisted of 4 interrelated variables; namely attitude, value, and behavior variables, cognitive skill variables, family variables, and personal variables, (3) teacher-level variables consisted of 4 interrelated variables; namely teacher characteristic variables, instructional behavior variables, teacher background variables, and learning environment variables, (4) the proposed structural equation model of critical thinking fit quite well with the empirical data set, (5) undergraduate student-level variables accounted for the variance of the critical thinking about 77%, emotional intelligence, internal locus of control, cognitive skills, and Thai ability significantly affected the critical thinking (total effects:

TE = 1.50, -0.82, -0.58, 0.14 respectively), and (6) major-level variables accounted for the variance of the critical thinking about 30%, learning environment, teaching methods promoting critical thinking, and teacher characteristics significantly affected the student's critical thinking (TE = 0.53, 0.46, 0.41 respectively).

Introduction

Critical thinking is the important skills and characteristics for human resources in diversity organization, society, and the world, in which rapidly changing, diversity, identity, and globalization. The critical thinking skills and dispositions, are judging in a reflective way what to do, or what to believe. The cognitive skills of analysis, interpretation, inference, explanation, evaluation, and of monitoring and correcting one's own reasoning are at the heart of critical thinking. Critical thinking is essential as a tool of inquiry. As such, critical thinking is a liberating force in education and a powerful resource in one's personal and civic life. While not synonymous with the good thinking, critical thinking is a pervasive and self-rectifying human phenomenon. The ideal critical thinker is habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biased, prudent on making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject, and the circumstances of inquiry permit. Thus, educating good critical thinkers means working toward this ideal. It combines developing critical thinking skills with nurturing those dispositions, which consistently yield useful insights and which are the basis of a rational and democratic society. (Reed, 1998; Facione, 1990; 2000, 2007)

The important research results of critical thinking in Thailand were as follows: Bamrungchat (2550) founded that critical thinking effected media literacy on television advertising. The students with high critical thinking scores had the high scores of seeing through tricks or ideas of television advertising Medias. Chantarachot (2550) asserted that critical thinking correlated with problem-solving thinking, reflective thinking, and resulting-based thinking. Tantiyanukul (2547) concluded that critical thinking effected to achievement and problem-solving competence. Runkham (2544) asserted that critical

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thinking effected to problem-solving competence. Chaisuriya (2543) stated that critical thinking correlated with critical reading. Sa-nunoue (2542) founded that critical thinking affected to achievement and problem-solving competence. Boonchim (2541) had resulted that critical thinking could accounted logical competence about 73%, correlated with logical competence, classification competence, analogy competence, picture alphabetically competence, summarization competence, and analyticity competence.

Definition of Critical Thinking

Halpern (1993); Reed (1998) stated that critical thinking most related with higher order thinking, Beyer (1985); Facione (1984); R. H. Johnson (1996); Perkins, Farady, and Bushey (1991); Resnick (1987) mentioned that critical thinking correlated with thinking skills, informal logic, informal reasoning, problem solving, argumentation, critical reflection, reflective judgment, and meta-cognition (Reed, 1998), while Facione (1990); Reed (1998) asserted that critical thinking was the other kind of decision making, and creative thinking.

Definition terms and factors of critical thinking had concluded by American Philosophical Association, Delphi method research project as which the qualitative research and the researcher was Facione (1990). In this study attempted to achieve a consensus by a panel of experts in critical thinking for the purpose of educational instruction and assessment. E-mail method was employed data collection of expert's opinion in 2 years. The forty-six experts were keeping referring to included men and women of American Philosophical Association memberships from throughout the United States and Canada. About half of the participants were philosophers 52%, and the rest were affiliated with education 22%, the social sciences including psychology 20%, and the physical sciences 6%.

The results of the Delphi-technique concluded that critical thinking was the process of purposeful, self-regulatory judgment. This process reasoned consideration to evidence, context, conceptualizations, methods, and criteria. Critical thinking is judgment, which results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based. Critical thinking is essential as a tool of inquiry. As such, critical thinking is a liberating force in education and a powerful resource in one's personal and civic life. Future more, critical thinking is a pervasive and self-rectifying human phenomenon.

The critical thinking dispositions, the ideal critical thinker is habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit. These characteristics are essential and which are the basis of a rational and democratic society. Conceptualization of critical thinking terms of two dimensions are cognitive skills and affective dispositions. As well as, critical thinking consists of two factors: critical thinking skills, and critical thinking dispositions. The experts of critical thinking definitions had consensuses that higher order thinking was thinking skills and its relationship to critical thinking, problem-solving thinking, and decision making thinking. Critical thinking and problem solving thinking as equivalent terms or one as a subset of the other, in which its means the judgment based rationality, argumentation, and ill-structured problem (Reed, 1998; Facione, 1990; 2007).

Factors of Critical Thinking

Facione, Facione, and Giancarlo (2000); Facione (2007); Reed (1998); Ricketts, and Rudd (2005); Myer, and Dyer (2006) mentioned that critical thinking was thinking process which using data, knowledge, experience, and social situations for making decision and conclusion. Critical thinking was purposeful, self-regulatory judgment that results in interpretation, analysis, evaluation, and inference, as well as explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations upon which that judgment is based. Critical thinking consists of 2 factors as follows:

1. Critical thinking skills are judgment, deliberate, reflective, and purposive thinking in academic and real-word situations. Critical thinking skills consist of 6 factors: 1.1) Interpretation skill mentions to comprehend and express the meaning or significance of a wide variety of experience, situation, data, event, judgment, convention, belief, rule, procedure, or criteria. Interpretation includes the sub-skills of categorization, decoding significance, and clarifying meaning. 1.2) Analysis skill defines to identify the intended and actual inferential relationship among statement, question, concept, description, or other forms of representation intended to express belief, judgment, experience, reason, information, or opinion. Include examining ideas, detecting arguments, and analyzing arguments as sub-skills of analysis skill. 1.3) Evaluation skill indicates

to assess the credibility of statements or other representations which are accounts or descriptions of a person's perception, experience, situation, judgment, belief, or opinion; and to assess the logical strength of the actual or intended inferential relationships among statements, descriptions, questions or other forms of representation. 1.4) Inference skill mentions to identify and secure elements needed to draw reasonable conclusions; to form conjectures and hypothesis; to consider relevant information; and to deduce the consequences flowing from data, statement, principle, evidence, judgment, belief, opinion, concept, description, question, or other forms of representation. As sub-skills of inference skill, querying evidence, conjecturing alternative, and drawing conclusion. 1.5) Explanation skill defines as being able to present in a cogent and coherent way the results of one's reasoning. This means to be able to give someone a full look at the big picture: both to state and to justify that reasoning in term of the evidential, conceptual, methodological, criteriological, and contextual considerations upon which one's reasoning in the form of cogent arguments. The sub-skills under explanation are describing methods and results, justifying procedure, proposing and defending with good reason one's causal and conceptual explanations of events or points of view, and presenting full and well-reasoned, arguments in the context of seeking the best understandings possible. 1.6) Meta-cognition self-regulation skill defines to mean self-consciously to monitor one's cognitive activities, the elements used in those activities, and the results deduced, particularly by applying skills in analysis, and evaluation to one's own inferential judgments with a view toward questioning, confirming, validating, or correcting either one's reasoning or one's results. The two sub-skills here are self-examination and self-correction.

2. Critical thinking dispositions are personal characteristics as which personality is identifying in thinking methods, rationality, and judgment along with real-world situations. Critical thinking dispositions are personal characteristics according to others' perception, and its characteristics promoting the development process of cognitive skills. This dispositions consist of 7 factors: 2.1) Truth-seeking means the inquiry habit, the curiosity of world-view knowledge, the intellectual honesty, the courageous desire for best knowledge in any situation, the inclination to ask challenging question, the goal setting of persisted inquiry process, and to follow the reasons and evidence wherever they lead, and the meta-cognition thinking of facts, results, and knowledge when had new information. 2.2) Open-mind defines the tolerance for new ideas and divergent views, the unbiased mind to the different

values, habits, opinions, ideas, or attitudes, and the sensitivity of biased feeling. 2.3) Analyticity mentions the alertness to potential difficulties, being alert to the need to intervene by the use of reason and evidence to solve problems, the habit of diligence to analyze data, event, situation, or new knowledge, the rational consideration of information essentiality, and the competence using of information interpretation, future situation scenarios, knowledge integration between observation results and theoretical knowledge. 2.4) Systematicity indicates the inclination to be organized, focused, diligent, and preserving in inquiry, the habit of usually systematic working, setting plan regularly, being often step by step behavior, and well-structure of plan, project, and strategy. 2.5) Critical thinking self-confidence means the trust in one's own reasoning, and in one's ability to guide the others to make reasoned decisions, the habit of individual personality, the self-confidence of thinking, action, and behavior, the confidence of judgment or decision making in which evaluate that its accurate, and the self-assessment of critical thinking skills as which detecting over-estimation and under-estimation. 2.6) Inquisitiveness refers the intellectual curiosity, and the intention to learn things even if their immediate application is not apparent. 2.7) Maturity indicates the judiciousness, which inclines one to see the complexity in problems, and to desire prudent and timely decision making, even in uncertain conditions, the habit of usually setting many choices of solution, and being judgment based standard, norm, tradition, and social ethic.

Methodology

Objectives of the research

The purposes of this research were: (1) to synthesize the body of knowledge resulting from critical thinking research (2) to develop and validate the critical thinking model (3) to develop and validate the causal model with factors affecting critical thinking.

Data collection and data analysis

Stage 1 The 86 thesis, dissertations, and research reports related critical thinking were subjects of this study. Research quality evaluative form and research characteristics coding form were employed for data collection. Meta-Analysis and content analysis were employed for data analysis using SPSS. The computation of effect size values (d) of meta-analysis technique using r , t , and F statistics employed Cohen's formulas. (Cooper, and Hedges, 1994)

Stage 2 The undergraduate student samples for structural equation model (SEM) validation consisted of 1,872 second year undergraduate students, selected by multi-stage random sampling from 90

classrooms, 5 faculties and 7 fields of 3 Rajabhat Universities in Bangkok area, Ban Somdej Jaopraya Rajabhat University about 41%, Dhonburi Rajabhat University about 32%, and Suan Sunandha Rajabhat University about 27%. Student's field of study were (1) business students about 37%, (2) human and social science students about 18%, (3) communication art students about 14%, (4) education students about 9%, (5) industrial technology students about 9%, (6) fine and applied art students about 7%, and (7) science and technology students about 6%. Grade point average (GPAX) of the research sample students were GPAX = 2.51- 3.00 about 29%, GPAX > 3.50 about 25%, GPAX = 2.01 – 2.50 about 25%, GPAX = 3.01 – 3.50 about 15%, GPAX < 2.01 about 6%. Sex of the sample students was female about 57%.

Questionnaires, and tests form were employed for data collection. Confirmatory factor analysis and structural equation model were employed for data analysis using LISREL program. Data analysis for this research model validation was accounted with the large size sample, 1,872 students. The accuracy and efficiency goodness of fit indexes for evaluate the causal model validation were (1) GFI index, goodness of fit, value > 0.90, (2) CFI index, comparative fit index, value > 0.90, (3) RMSEA index, root mean square error of approximation, value < 0.05, and (4) RMR index, root mean square residual, value < 0.05. According to research model, validation carried out using SEM, which employed LISREL program, had biased parameter estimation of chi-square statistic. (Angsuchot, Wijitwanna, and Pinyopanuwat, 2551)

Results

1. Results of Content Analysis

The content analysis technique was employed to synthesize research results about factors affecting critical thinking. All of research reports, 86 projects, were published in B.C. 2532 – 2550. Results of content analysis technique found that most research projects studied in B.C. 2542 – 2548. The research themes were teaching methods 52 projects (57.14%), teacher characteristics 6 projects (6.59%), and student characteristics 33 projects (36.26%). Multilevel model, individual-level predictor variables and classroom-level predictor variables, were employed five projects (5.49%). The t-test statistics were employed 50 projects (58.14%), F-test statistics were employed 17 projects (19.77%), correlation coefficients were employed 12 projects (13.95%), multiple regression analysis were employed 5 projects (5.81%), and structural equation model (SEM) 2 projects (2.33%). The research samples were elementary students 12 projects (13.95%), secondary students 49 projects

(56.98%), vocational students 6 projects (6.98%), and undergraduate students 19 projects (22.09%).

2. Results of Meta-Analysis

The results of meta-analysis technique concluded that factors affecting student's critical thinking consisted of three factors were (1) teaching method factors, (2) teacher characteristic factors, and (3) student characteristic factors. The results of effect size computation were presented in figure 1. The effect size computation of teaching method factors were presented in table 1. Teacher characteristic factors' effect size was presented in figure 2. Student characteristic factors affecting critical thinking consisted of four variables; (1) personal factors (2) family factors (3) attitude, value, and behavior factors, and (4) cognitive competence factors. Effect sizes of student characteristics were presented in figures 3 – 7.

(See all figures and tables in last page)

1) Teaching Methods ($\bar{d} = 2.210$) The conclusions of research synthesis were integration teaching method according to the National Education Act B.E. 2542, critical thinking training program, collaborative learning, mediated learning experience instruction, Robert S. Ennis theory, philosophical inquiry activity, case study, historical method, experience-based learning, De Bono's six thinking hats approach, and 4MAT method effected critical thinking of students at the high level. Effect size findings were presented in table 1.

2) Teacher Characteristics ($\bar{d} = 0.723$) The results of research synthesis were teacher personality, and teaching behaviors effected student's critical thinking at the high level, while teacher education, and learning environment effected critical thinking at the moderate level. Effect size finding were presented in figure 2.

3) Student Characteristics ($\bar{d} = 0.789$) Consist of attitude, value, and behavior factors, cognitive competence factors, family context factors, and personal characteristic factors. The findings of research synthesis were attitude, value, and behavior factors, and cognitive competence factors affected critical thinking at the high level, while family context and personal characteristic factors effected to critical thinking at the low level. Effect size finding were presented in figure 3.

3.1) Attitude, Value, and Behaviors ($\bar{d} = 1.420$) The findings of research synthesis were emotional intelligence, intrinsic motivation, internal locus of control, inquisitiveness, self-awareness, self-regulation, and learning habits effected to critical thinking at the high level. Self-concept affected to critical thinking at the

moderate level, while learning styles, and work performance competence effected to critical thinking at the low level. Effect size finding were presented in figure 4.

3.2) Cognitive Competence ($\bar{d} = 1.217$) The results of research synthesis were meta-cognition thinking, problem-solving competence, calculation skills, numeric competence, reasoning aptitude, cognitive skills, achievement, and language competence effected to critical thinking at the high level. Automatic information processing ability, and problem-solving thinking effected to critical thinking at the moderate level, while resulting thinking, reflective thinking, and integrated scientific process skills affected to critical thinking at the low level. Effect size finding were presented in figure 5.

3.3) Family Context ($\bar{d} = 0.314$) The results of research synthesis were family relationship effected to critical thinking at the moderate level, while parenting, parent education, and family status effected to critical thinking at the low level. Effect size finding presenting in figure 6.

3.4) Personal Characteristics ($\bar{d} = 0.203$) The results of research synthesis were sex, fields of study, age, and years of study effected to critical thinking at the low level. Effect size findings were presented in figure 7.

3. Results of SEM Model Validation

Research conceptual framework in this study based on research synthesis results of factors affecting critical thinking, CT. The results were synthesized research projects had published in B.C. 2532 – 2550. Multilevel model and structural equation model (SEM) were employed to setting research conceptual framework, data analysis, and research conclusions. The student-level factors consisted of 4 variables were (1) cognitive skills, COG (2) Thai ability, THAI (3) emotional intelligence, EMO (4) internal locus of control, LOCUS. The major-level factors consisted of 3 variables were (1) teaching methods, TEACH (2) learning environment, ENV (3) teacher characteristics, CHAR.

3.1 Student-Level Model

Proposal model validation with the empirical data of the causal model of student factors affecting critical thinking employed LISREL version 8.72. The finding was student-level model nicely fitted to the empirical data. ($\chi^2 = 1421.89$; $\chi^2/df = 2.950$; RMSEA = 0.032; RMR = 0.039; GFI = 0.96; AGFI = 0.95; NIF = 0.94; CFI = 0.96) Parameter estimation results

of regression coefficients indicated that (1) Emotional intelligence most effected to critical thinking (TE=0.78), internal locus of control (TE= -0.29), Thai ability (TE=0.20), and cognitive skills (TE=0.10) respectively. (2) Emotional intelligence most effected to internal locust of control (TE=0.80), the second was cognitive skills. (TE=0.17) (3) Cognitive skills effected to Thai ability. (TE=0.87) (4) The predictor variables at the student-levels accounted for the variance of the student's critical thinking about 69%, accounted for the variance of the student's internal locus of control about 75%, and accounted for the variance of the student's Thai ability about 75%.

Parameter estimation results of factor loadings founded that (1) Interpretation skill, analysis skill, evaluation skill, self-regulation skill, truth-seeking, open-mindedness, analyticity, systematicity, critical thinking self-confidence, inquisitiveness, and maturity of judgment significantly explained for the variance of the critical thinking at the level 0.05. ($\beta = 0.07 - 0.62$; $R^2 = 0.02 - 0.38$) (2) Observing, explaining, comparing and contrasting, developing concept, differentiating, defining, generalizing, predicting, hypothesizing, and offering alternative skills significantly explained for the variance of the cognitive skills at the level 0.05. ($\beta = 0.13 - 0.55$; $R^2 = 0.02 - 0.30$) (3) Self-awareness, self-regulation, motivation, empathy, and social skills significantly explained for the variance of the emotional intelligence at the level 0.05. ($\beta = 0.49 - 0.79$; $R^2 = 0.24 - 0.63$) (4) Believing in self-intellectual competence, believing in study behaviors, and don't believing in destiny and fate or external locus of control, significantly explained for the variance of the internal locus of control at the level 0.05. ($\beta = 0.15 - 0.82$; $R^2 = 0.02 - 0.67$) (5) Completely word or sentence, language analogy and metaphor, and critical reading significantly explained for the variance of the Thai ability at the level 0.05 ($\beta = 0.38 - 0.46$; $R^2 = 0.1 - 0.21$). The parameter estimation findings were presented picture 8 and table 2.

3.2 Major-Level Model

The results of model validation with the empirical data of the cause and effect model of major-level factors affecting critical thinking indicated that major-level model fitted quite well with the empirical data set. ($\chi^2 = 392.10$; $\chi^2/df = 2.293$; RMSEA = 0.0026; RMR = 0.021; GFI = 0.98; AGFI = 0.97; NFI = 0.99; CFI = 0.99) Parameter estimation results of regression coefficients founded that (1) Learning environment most effected to student's critical thinking (TE=0.53), the teaching methods promoting critical thinking (TE= 0.46), and the teacher characteristics (TE=0.41), respectively. (2) Teacher characteristics most effected to student's critical

thinking (TE=0.88), the second was teaching methods promoting critical thinking. (TE=0.42) (3) Teacher characteristics effected to student's critical thinking. (TE=0.75) (4) The predictor variables at the major-levels accounted for the variance of the student's critical thinking about 30%, accounted for the variance of the teaching methods promoting critical thinking about 56%, and accounted for the variance of the learning environment about 72%.

Parameter estimation results of factor loadings founded that (1) Evaluation skill, self-regulation skill, truth-seeking, open-mindedness, analyticity, systematicity, critical thinking self-confidence, inquisitiveness, and maturity of judgment significantly explained for the variance of the critical thinking at the level 0.05. ($\beta = 0.11 - 0.80$; $R^2 = 0.01 - 0.64$) (2) Intrinsic motivation and inquisitiveness based method, self-inquiry method, group activity method, questioning method, and integration method significantly explained for the variance of the teaching methods promoting critical thinking at the level 0.05. ($\beta = 0.78 - 0.83$; $R^2 = 0.61 - 0.68$) (3) Physical environment, relationship of teachers and students, and relationship of students and friend significantly explained for the variance of the learning environment at the level 0.05. ($\beta = 0.53 - 0.74$; $R^2 = 0.28 - 0.55$) (4) Teacher personality, teaching competence, and teaching behaviors significantly explained for the variance of the teacher characteristics at the level 0.05 ($\beta = 0.78 - 0.90$; $R^2 = 0.61 - 0.81$). The parameter estimation results were presented picture 9 and table 3.

Discussion

The study of cause and effect of student-level factors affecting critical thinking founded that emotional intelligence had positive effected to critical thinking at the high level (TE = 1.65), while internal locus of control had negative effected to critical thinking at the high level (TE = -0.97). These results indicated that thinking, emotion, affection, and environment had correlated with others at the high level. Quality thinking, efficiency thinking, effective thinking, good thinking, and standard thinking had emerged from cognitive maturity, emotional maturity, kindness mind, and good social environment. Thus, promoting and developing student's critical thinking essential educated simultaneously critical thinking along with emotional intelligence.

This research results about the effect of emotional intelligence to student's critical thinking according to the results of Kaojikan (2549) asserted that sub-dispositions of emotional intelligence were self-awareness, and self-regulation correlated with student's critical thinking ($p < .01$). Student's self-regulation had direct effected to critical thinking, the

student's self-awareness had indirect effected to critical thinking with the mediated effect of self-regulation. Moolphol (2547) concluded that emotional intelligence, self-awareness, self-regulation, intrinsic motivation, empathy, and social skills had correlated with critical thinking at the high level ($p < .01$). Its results according to the research synthesis results, as which emotional intelligence affecting critical thinking at the high level ($\bar{d} = 3.893$).

The results of studying cause and effect of major-level factors affecting student's critical thinking indicated that major management context affected to student's critical thinking at the moderated level. Learning environment had most effected to student's critical thinking, teaching methods, and teacher characteristics, respectively (TE = 0.73, 0.52, 0.45, respectively). This results indicated that all of major context factors were teaching methods promoting critical thinking, well setting of learning or academic environment, and personal characteristics of teachers, were essentially to develop student's critical thinking skills and critical thinking dispositions. The teaching methods had promoted student's critical thinking, were group activity method, integrated learning method, questioning method, intrinsic motivation based method, and self-inquiry method. Furthermore, good relationship between students and friend, students and teachers, were learning environment-promoting student's critical thinking. The essential issues were teacher characteristics, expertise in field of study, instructional competence, teaching skills, nicely personality, rational action, well-informed skills, prudent judgment, kindness, student-based learning, optimistic person, and well emotional management, all of those had promoted student's critical thinking.

This research results can conclude that learning environment affecting critical thinking. The results had asserted with the study of Ngamrayab (2548) founded that learning environment correlated to analyticity reasoning thinking ($p < .01$), Leebonoi (2547) stated that relationship between student and friend correlated with critical thinking ($p < .01$), along with the research synthesis results which indicated that learning environment effected to student's critical thinking at the moderate level ($\bar{d} = 0.523$).

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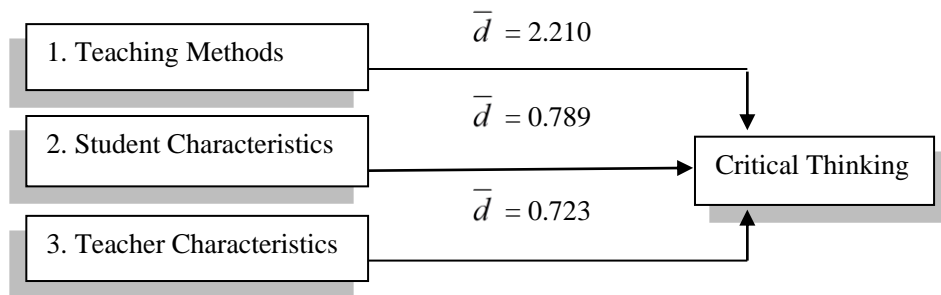


Figure 1: Factors Affecting Critical Thinking

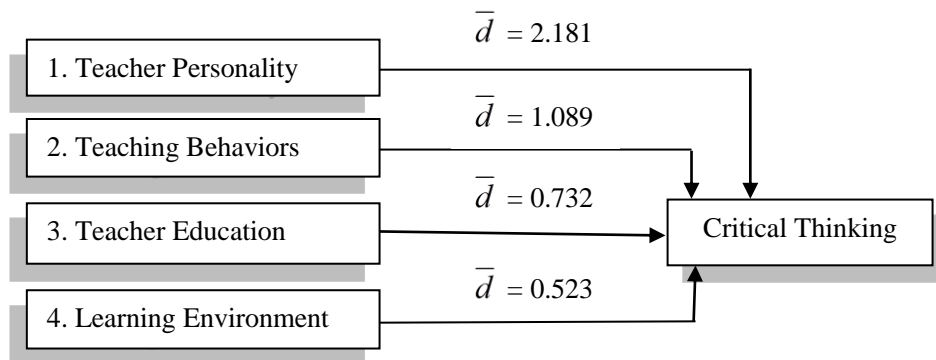


Figure 2: Teacher Characteristics Affecting Critical Thinking

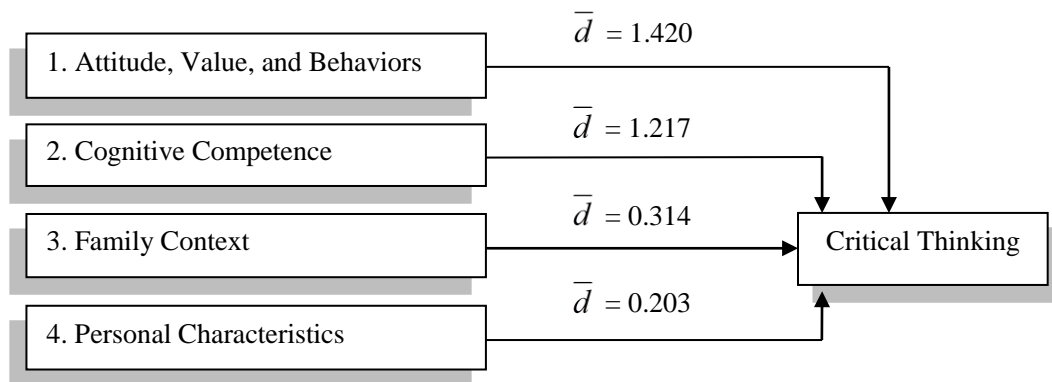


Figure 3: Student Characteristics Affecting Critical Thinking

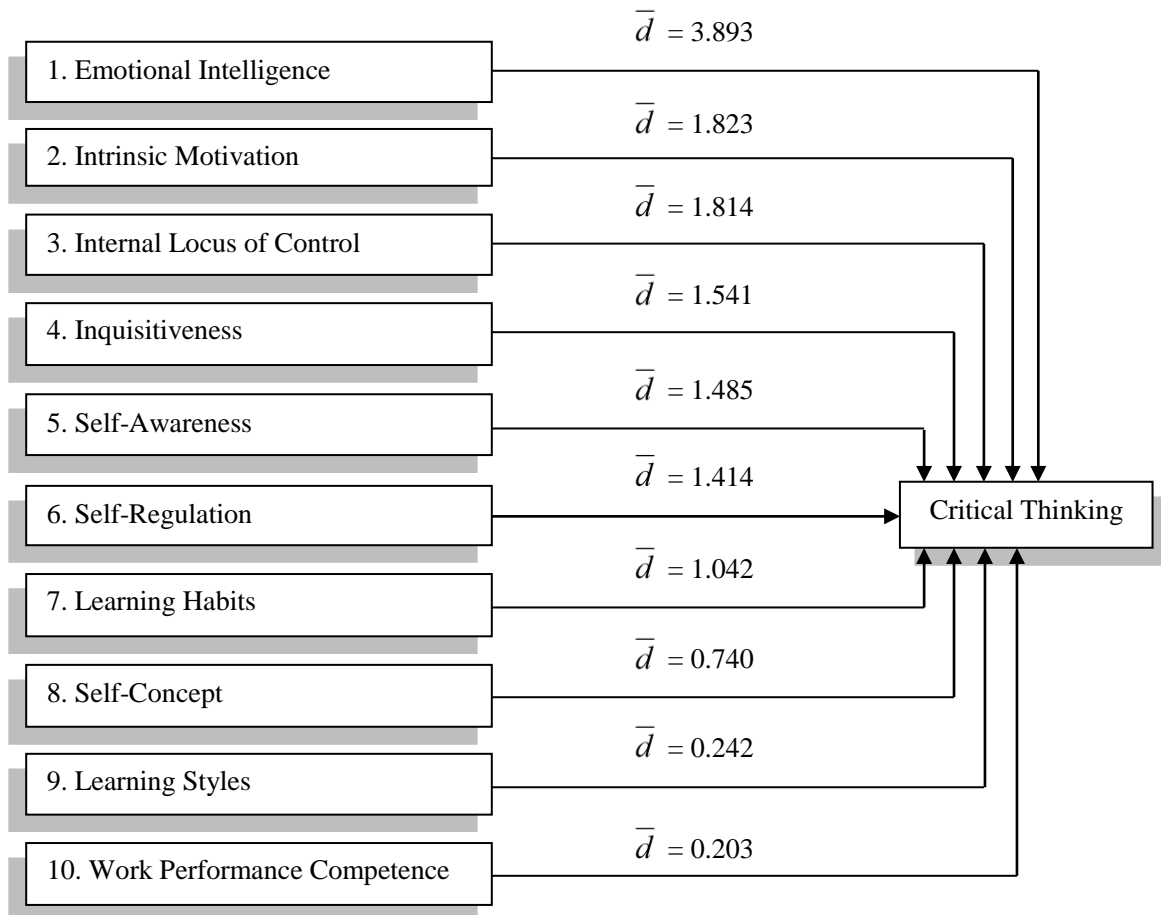


Figure 4: Attitude, Value, and Behavior of Students Affecting Critical Thinking

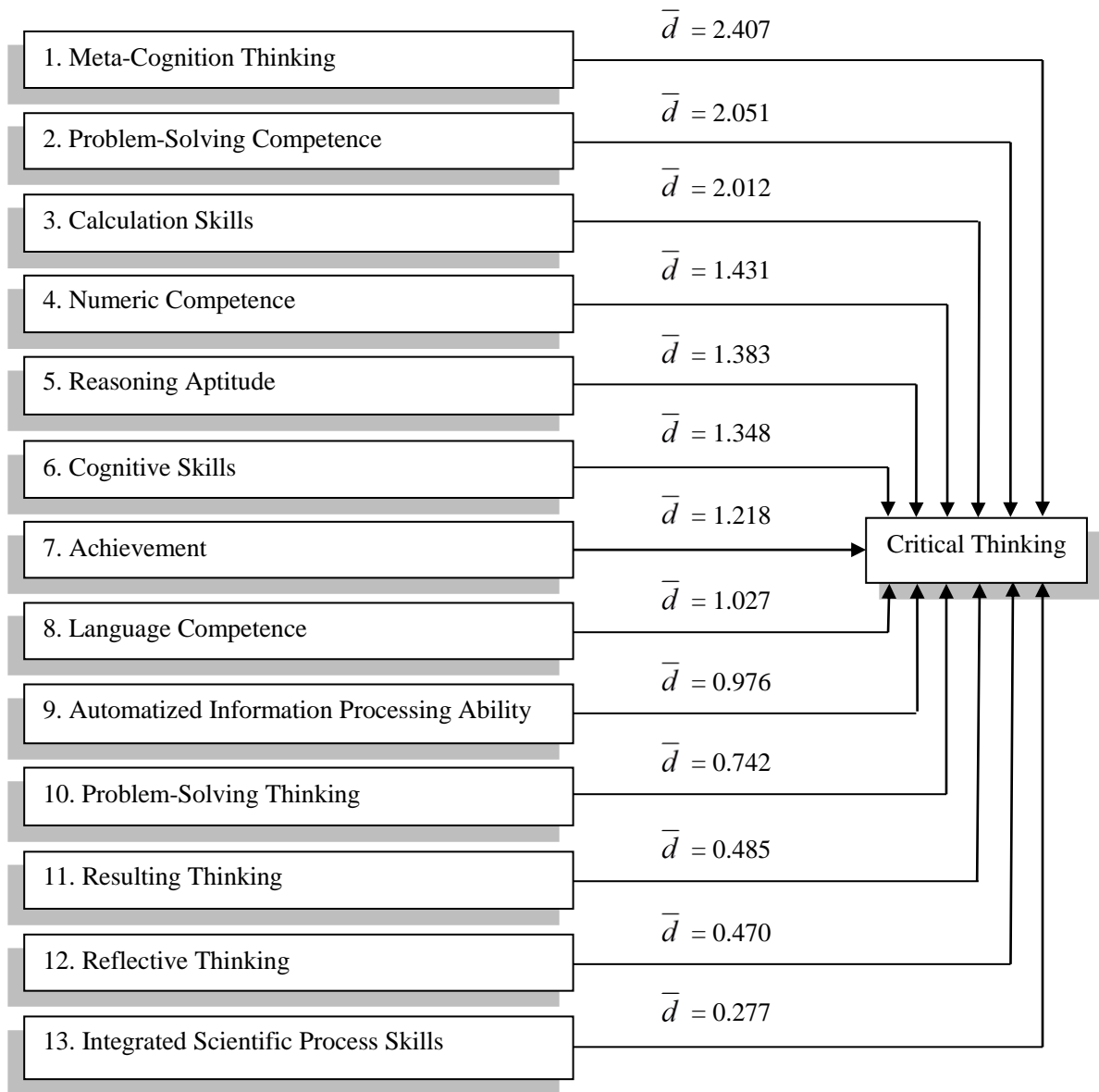


Figure 5: Cognitive Competence of Students Affecting Critical Thinking

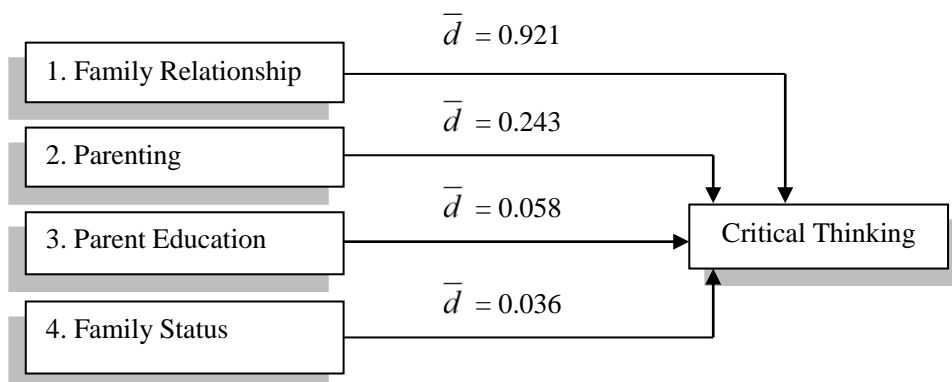


Figure 6: Family Context of Students Affecting Critical Thinking

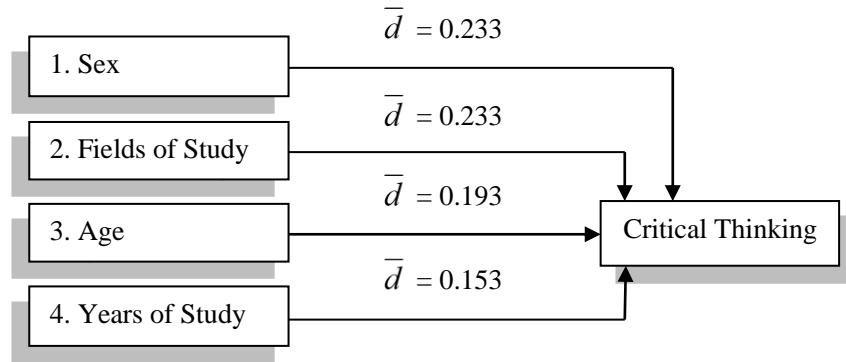


Figure 7: Personal Characteristics of Students Affecting Critical Thinking

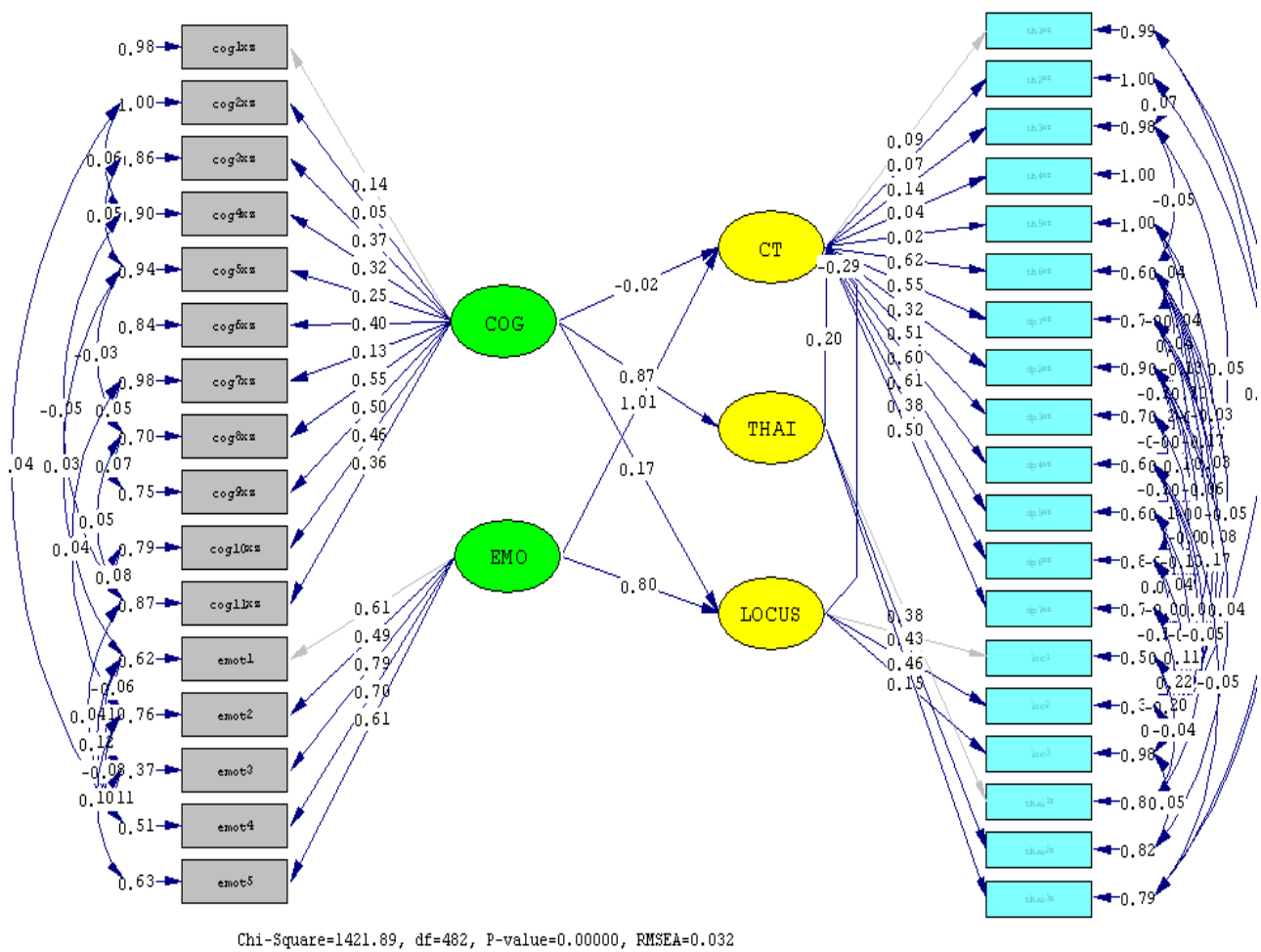


Figure 8: The Causal Model of Student-Level Factors Affecting Critical Thinking

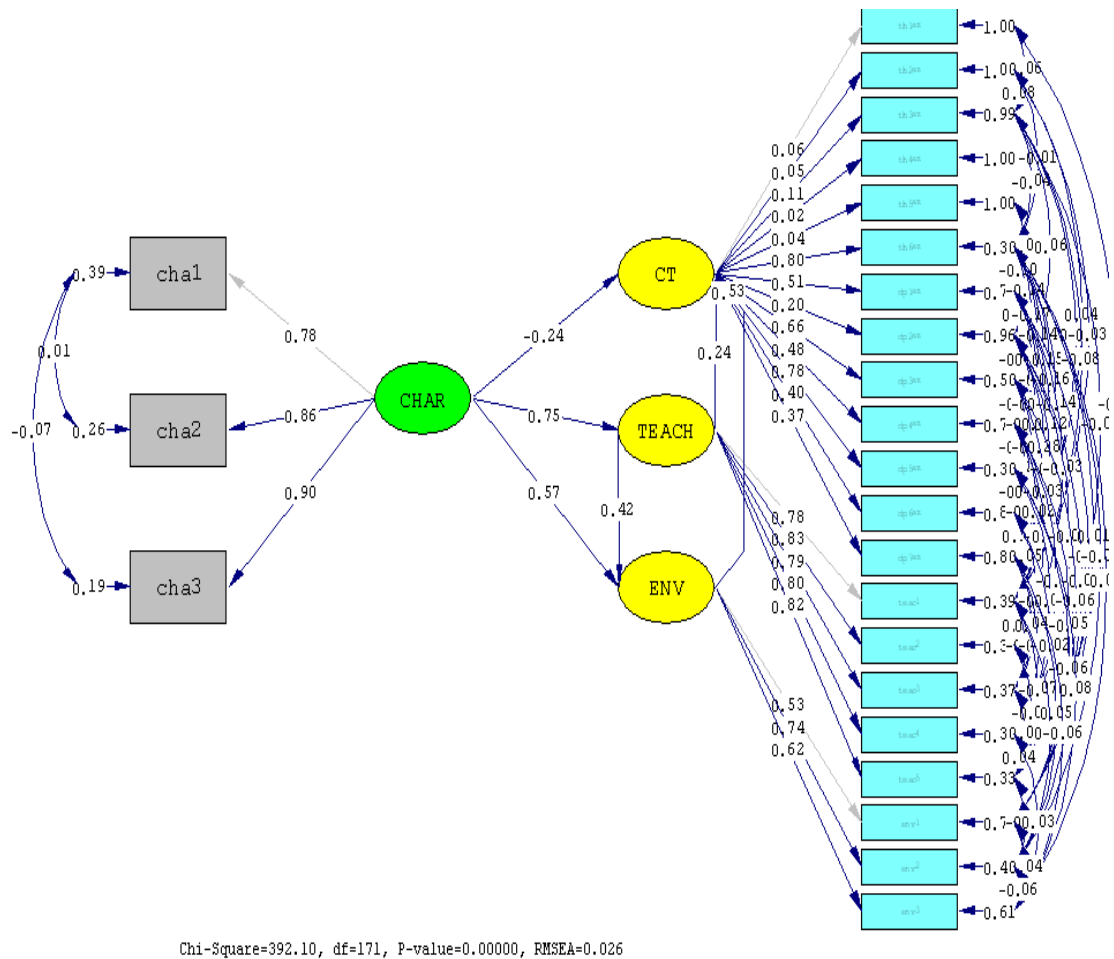


Figure 9: The Cause and Effect Model of Major-Level Factors Affecting Critical Thinking

Table 1: Teaching Methods Affecting Critical Thinking

Teaching Methods	\bar{d}	Teaching Methods	\bar{d}
1. Integration Teaching according to The National Education Act B.E. 2542	45.78	19. Guilford Theory	0.655
2. Critical Thinking Training Program	4.335	20. Higher Order Thinking Training Method	0.638
3. Collaborative Learning	3.907	21. Syndicate Method	0.607
4. Mediated Learning Experience Instruction	2.944	22. Buddhism Thinking Method	0.601
5. Robert S. Ennis Theory	1.815	23. Empowerment Instruction	0.562
6. Philosophical Inquiry Activity	1.801	24. Stenberg Theory	0.398
7. Case Study	1.711	25. Integration Method	0.369
8. Historical Method	1.706	26. Angelo and Cross's Classroom Assessment Techniques	0.337
9. Experience-Based Learning	1.580	27. The Four Noble Truth Method	0.315
10. De Bono's Six Thinking Hats Approach	1.463	28. Yonisomanasikara Principles	0.242
11. Web-based Instruction	1.262	29. Thinking Styles Training	0.225
12. 4MAT Method	1.066	30. Simulation Method	0.213
13. CIPPA Model	0.949	31. Forecasting Technique	0.213
14. Graphic Organizers Technique	0.865	32. Group Discussion Method	0.086
15. Concept Mapping Technique	0.738	33. Learning Support Method	0.076
16. Jurisprudential Inquiry Teaching Model	0.674	34. Storyline Method	0.063
17. Inquiry Method	0.667	35. Problem-Based Learning	0.041
18. Constructivism	0.665	36. Problem Scenarios Web-Based Instruction	0.007

Note: \bar{d} is the effect size mean of meta-analysis results, data analysis employed through r, t, F statistics

Table 2: Parameter Estimated Results of the Causal Model of Student-Level Factors Affecting Undergraduate Students' Critical Thinking

Causal Effects	Critical Thinking			Internal Locus of Control			Thai Ability		
	DE	IE	TE	DE	IE	TE	DE	IE	TE
1. Cognitive Skills	-0.02	0.12	0.10	0.17*	-	0.17	0.87*	-	0.87
2. Emotional Intelligence	1.01*	-0.23	0.78	0.17*	-	0.80			
3. Internal Locus of Control	-.029*	-	-0.29						
4. Thai Ability	0.20	-	0.20						
Correlation Matrix of Latent Variables									
		1		2		3		4	
1. Critical Thinking		1.00							
2. Thai Ability		0.33		1.00					
3. Internal Locus of Control		0.63		0.35		1.00			
4. Cognitive Skills		0.33		0.87		0.41		1.00	
5. Emotional Intelligence		0.81		0.25		0.85		0.29	

Note: DE is direct effect, IE is indirect effect, and TE is total effect.

Table 3: Parameter Estimated Results of the Cause and Effect Model of Major-Level Factors Affecting Undergraduate Students' Critical Thinking

Causal Effects	Critical Thinking			Learning Environment			Teaching Methods		
	DE	IE	TE	DE	IE	TE	DE	IE	TE
1. Teaching Methods	0.24	0.22	0.46	0.42*	-	0.42			
2. Learning Environment	0.53*	-	0.53						
3. Teacher Characteristics	-0.24	0.65	0.41	0.57*	0.31	0.88	0.75*	-	0.75
Correlation Matrix of Latent Variables									
		1		2		3			
1. Critical Thinking		1.00							
2. Teaching Methods		0.51		1.00					
3. Learning Environment		0.52		0.84		1.00			
4. Teacher Characteristics		0.41		0.75		0.88			