An Empirical Study of Critical Thinking Quality Development in High School English Learners under the Cognitive Motivation Theory via SEM

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ABSTRACT Critical thinking quality has become an important topic in English education research. Based on cognitive motivation theory, this study proposes a theoretical framework for the development of critical thinking quality among high school English learners. The revised Chinese version of the Critical Thinking Disposition Inventory is used to survey 298 first-year high school students from Changsha Railway No. 1 Middle School and Shaoyang Wugang No. 1 Middle School. Structural equation modeling is employed for data analysis. Results show that the development levels of the seven dimensions of critical thinking quality, from highest to lowest, are maturity, open-mindedness, analyticity, truth-seeking, systematicity, inquisitiveness, and self-confidence. Path analysis shows that truth-seeking, open-mindedness, analyticity, self-confidence, inquisitiveness, and maturity have significant positive direct effects on the development of critical thinking quality. Systematicity shows a significant negative direct effect. Self-confidence has the strongest direct influence, followed by truth-seeking, maturity, inquisitiveness, analyticity, and open-mindedness. The study provides empirical evidence and a conceptual framework for cultivating critical thinking quality in high school English learning.

INDEX TERMS cognitive motivation theory, high school english learners, critical thinking quality, structural equation modeling, learning motivation

I. INTRODUCTION

WITH globalization and the information era, the fundamental goal of English education has changed to merely teaching students language skills and the entire process of developing the core competencies in students in a specific area of expertise.

The theory of cognitive motivation offers an integrative theoretical view to the study. According to this theory, cognitive processes and the motivational state of an individual are two fundamental and interrelated factors that impel them to learn and develop cognitive abilities. Development of critical thinking features cannot be defined as only an act of acquiring better thinking processing skills but an inseparable one with the help of certain affective inclinations and intrinsic motivation. Organically combining critical thinking tendencies (affective traits) with thinking qualities (cognitive performance) to form the composite construct of "critical thinking qualities" helps to more comprehensively and deeply reveal its structure and developmental patterns in the English learning context. Thus, the research questions in this study are the following: In the context of the cognitive motivation theory, what are the fundamental dimensions that make up the key characteristics of thinking of high school English learners? What impact do these dimensions have on their overall critical thinking attributes? Through responses to these questions, it is the hope of this study to produce empirical data and theoretical advice to successful growth and development of critical thinking attributes of students in English teaching at a high school level.

II. RELATED WORK

In current research on English teaching in high schools, learners' intrinsic motivation, self-efficacy and learning strategies have become core concerns. Dwinalida and Setiaji [1] found that there is a significant positive correlation between students' English learning motivation and academic achievement. Dewanti et al. [2] assessed how tasks and activities in textbooks cover various aspects of digital literacy through systematicity document analysis. Rohimajaya and Hamer [3] analyzed the principles and objectives of the Merdeka curriculum and explored how digital technology supports the achievement of these objectives in English teaching. Jiang and Liu [4] explored the relationship between Chinese high school students' English learning

aspirations (including two dimensions: path thinking and motivation thinking) and English learning efforts. Dewi et al. [5] found that the application of interactive e-learning modules in high school English learning has shown positive effects. These modules can improve students' learning motivation, participation and self-learning ability.

In an information-overloaded media environment, new media literacy has become crucial. Liu and Zhang [6] found that there is a significant positive correlation between students' new media literacy and their self-efficacy in English learning. Lee and Maeng [7] investigated high school students' views on using AI chatbots in English learning, including their perceived benefits, concerns and ethical considerations. Suganda [8] found that the use of digital media has a positive effect on improving junior high school students' English reading and writing skills. Digital media can provide richer and more authentic language input and attract students to participate in reading and writing activities in an interactive and interesting way. Chen and Sukying [9] found that there is a strong correlation between self-efficacy and self-regulation learning strategies. Zamzami et al. [10] explored the purpose, methods and effects of using poetry as a literary form in English learning.

Existing research focuses on the direct impact of motivation, strategies or technological tools on learning outcomes. While the aforementioned studies have revealed numerous factors influencing English learning outcomes from aspects such as motivation, strategies, and the use of digital tools, existing research mainly focuses on the direct impact of these factors on learning outcomes. The research on the inherent formation processes of higher-order Thinking Quality (particularly, critical thinking skill) and their profound linkage with cognitive motivation is still underdeveloped. Especially within the framework of the growing popularity of digital technology, the interaction between the critical thinking tendencies of learners (truth-seeking, inquisitiveness, self-confidence, etc.) and the conventional cognitive skills to create a unified compartment of their competence to think critically is currently empirically underexplored. This paper empirically investigates the dimensional structure of critically thinking ability and its influence through structural equation modeling (SEM), and attempts to reveal the formation process of the English critical thinking ability of high school students through the lens of interaction between affective dynamics and cognitive processes, and to fill the gaps of the literature in terms of core structure integration and quantitative path analysis.

III. METHODS

A. MEASURING TOOLS

This study used the Critical Thinking Inventory-CV (CTDI-CV) as the measurement tool. This scale is widely used internationally and has good reliability and validity. The scale contains 70 items, divided into seven dimensions, with 10 items per dimension. The seven dimensions are: Truth-seeking, Open-mindedness, Analyticity, systematicity, Self-confidence, Inquisitiveness, and Maturity. The scale uses a six-point Likert scale, with scores ranging from 1 to 6, from "Strongly Disagree" to "Strongly Agree". The score range for each dimension is 10 to 60, and the total score ranges from 70 to 420. Higher scores indicate a higher level of critical thinking quality in that dimension or overall. In this study, this scale was used to measure the level of critical thinking quality among high school English learners.

B. SAMPLE SELECTION

The empirical research started in March 2022 and concluded in early July. The participants in the study were first-year students in a middle school in Hunan Province (A and B). The sampling method used was cluster sampling and four classes were picked in middle school A and two classes in middle school B, bringing a total of six classes that took part in the survey. They included middle school A (two experimental and two control groups, 202 subjects) and middle school B (one experimental and one control group, 96 subjects). The conventional traditional teaching method and the experimental group were taught critical thinking and the traditional teaching method, respectively. In this study, 310 questionnaires were sent, and 298 valid questionnaires were returned with an effective recovery rate of 96.1. The total sample size was 298 people, including 152 boys and 146 girls, with an average age of 15.7 years (SD=0.68) [11].

C. DATA PROCESSING

The Critical Thinking Quality Scale was anonymously distributed and collected through the Wenjuanxing platform. Due to the use of a class-wide unified test, the questionnaire return rate was 100%. After the data collection was completed, SPSS 22.0 software was first used to perform descriptive statistical analysis and variance comparison analysis on the seven dimensions of critical thinking quality and the total score to understand the basic characteristics of the sample and the scores of each dimension. Subsequently, in order to test the reliability and validity of the scale, internal consistency reliability analysis and construct validity analysis were performed. On the basis of good reliability and validity, AMOS 22.0 software was used to perform structural equation model analysis to test the goodness of fit of the theoretical model and the path relationship of the influence of each dimension on critical thinking quality [12-13].

D. MODEL CONSTRUCTION AND ASSUMPTIONS

Based on seven dimensions of critical thinking quality (truth-seeking, open-mindedness, analyticity, systematicity, self-confidence, inquisitiveness, and maturity), this study constructed a structural equation model of critical thinking quality for high school English learners.

The seven dimensions are considered latent variables in the model and the observed items under the dimension are considered manifest variables. This study also seeks to confirm the direct effect route of these seven dimensions

on the quality of critical thinking of high school English learners by analyzing the results of the SEM [14-15].

According to the theoretical framework, this research suggests the following seven research hypotheses:

H1: Truth-seeking of high school students of English has a positive and significant effect on the quality of critical thinking.

H2: Open-mindedness positively and significantly influences the quality of critical thinking of high school English learners.

H3: Analyticity positively and significantly influences the quality of the critical thinking of high school English learners.

H4: Systematicity has a positive and significant impact on the critical thinking quality of high school English learners.

H5: Self-confidence is a important positive influence on the Quality of Critical Thinking of high school English learners.

H6: Inquisitiveness positively and significantly influences the quality of critical thinking of English learners in high schools.

H7: Maturity positively and significantly influences the quality of critical thinking of high school English learners.

IV. RESULTS AND DISCUSSION

A. DESCRIPTIVE STATISTICS AND SCALE RELIABILITY AND VALIDITY ANALYSIS

First, descriptive statistical analysis was performed on the sample data. As shown in Table 1, among the seven dimensions, maturity (M=40.03, SD=8.63) and open-mindedness (M=38.05, SD=7.58) had relatively high average scores, while confidence (M=30.35, SD=7.41) and inquisitiveness (M=31.68, SD=6.66) had relatively low average scores. This indicates that the surveyed high school students performed well in terms of prudence in critical thinking and willingness to accept different viewpoints, but there is significant room for improvement in their confidence in their critical thinking abilities and their desire for proactive inquiry in English learning. The skewness and kurtosis coefficients of all dimensions indicate that the data distribution basically conforms to the normal distribution assumption, making it suitable for subsequent model analysis.

Secondly, the reliability and validity of the scale were tested. Internal consistency reliability analysis showed (see Table 2) that the α coefficients of each dimension of critical thinking quality ranged from 0.723 to 0.850, and the combined reliability (CR) values ranged from 0.778 to 0.864, indicating that the scale has very good internal consistency and reliability.

Regarding construct validity, the Pearson correlation coefficients among all dimensions were all significant at a level less than 0.01 (see Table 3).

Furthermore, the square root of the mean variance extracted (AVE) is greater than the correlation coefficient between this dimension and other dimensions (see Table 4), indicating that the scale has good discriminant validity and convergent validity.

B. STRUCTURAL EQUATION MODELING ANALYSIS AND HYPOTHESIS TESTING

Based on ensuring the quality of the measurement model, the structural model was fitted and tested. After project screening and model correction, the initial model achieved good or excellent levels in all fitting indices (CMIN/DF=4.368, RMSEA=0.016, GFI=0.813, CFI=0.987, TLI=0.955), indicating that the corrected model fits the observation data well.

The hypothesis testing results for the model path relationships are shown in Table 5. Based on the critical ratio (CR) and significance level (p-value), six of the seven hypotheses were supported, and one was rejected.

Specifically, truth-seeking (Estimate=1.943, p<0.001), open-mindedness (Estimate=0.809, p=0.001), analyticity ability (Estimate=1.589, p<0.001), self-confidence (Estimate=2.374, p<0.001), inquisitiveness (Estimate=1.722, p<0.001), and maturity (Estimate=2.149, p<0.001) all have significant positive direct impacts on critical thinking qualities. However, systematicity (Estimate=-1.633, p=0.005) has a significant negative direct impact on critical thinking qualities, contrary to hypothesis H4.

C. IMPACT ANALYSIS AND DISCUSSION

To further quantify the impact of each dimension, standardized direct effect values were calculated. Since in this model, the seven dimensions, as causal variables, directly point to the outcome variable of critical thinking quality, and there is no mediating path, the direct effect is equal to the total effect. The standardized direct effect values of each dimension on critical thinking quality are shown in Table 6.

In terms of effect size ranking, confidence (0.476) had the greatest impact, followed by truth-seeking (0.415), maturity (0.386), inquisitiveness (0.278), systematicity (0.257), analyticity ability (0.243) and open-mindedness (0.178).

The implications of this finding are far reaching. To begin with, self-confidence is the most important variable that affects critical thinking quality. This indicates that in high school English learning, learners' confidence and belief in their ability to analyze and solve problems using critical thinking is the core driving force for the development of their critical Thinking Quality. Students with low self-confidence, although they may have some of the element of analyticity, might be shy and fearful of the need to challenge or go into details when presented with complicated language contents or perspectives. Thus, the teaching process of English must be aimed at the establishment of a safe psychological space and the gradual increase of the self-efficacy of students to use English to think critically with the help of designing tasks and positive feedback.

Secondly, the high positive influence of truth-seeking and maturity resonates with the nature of critical thinking, the pursuit of the truth and judiciousness. The attitude of high

TABLE 1. Descriptive statistical analysis of the dimensions of critical thinking quality (N=298)

Variable	N	Minimum Value	Maximum Value	Mean	Standard Deviation	Kudo	Skewness
Truth-seeking	298	10	50	34.13	8.05	-0.5321	0.2682
Open-mindedness	298	10	54	38.05	7.58	-0.8293	1.3835
Analyticity	298	10	47	32.32	6.39	-0.5975	0.6437
Systematicity	298	10	48	32.99	6.63	-0.9617	1.7950
Confidence	298	10	46	30.35	7.41	-0.5239	0.0493
Inquisitiveness	298	10	58	31.68	6.66	-0.3257	1.5560
Maturity	298	10	57	40.03	8.63	-0.8723	1.1752
Total Score	298	70	592	316.51	122.19	0.7245	-0.8374

TABLE 2. Internal consistency reliability coefficient of the Critical Thinking Quality Scale

Structural Variables	Number of Questions	Cronbach's α	Combined Reliability (CR)
Truth-seeking	10	0.811	0.864
Open-mindedness	10	0.766	0.838
Analyticity	10	0.723	0.778
Systematicity	10	0.731	0.843
Confidence	10	0.830	0.816
Inquisitiveness	10	0.746	0.844
Maturity	10	0.850	0.843

TABLE 3. Pearson correlation analysis for each dimension

Dimension	Truth-seeking	Open-mindedness	Analyticity	Systematicity	Confidence	Inquisitiveness	Maturity	Overall
Truth-seeking	1							
Open-mindedness	.527**	1						
Analyticity	.344**	.503**	1					
Systematicity	.565**	.447**	.549**	1				
Confidence	.331**	.310**	.471**	.572**	1			
Inquisitiveness	.385**	.365**	.452**	.607**	.641**	1		
Maturity	.571**	.447**	.309**	.583**	.289**	.507**	1	
Overall	.172**	.379**	.423**	.287**	.222**	.191**	.165**	1

Note: * $p < 0.05$ indicates a significant correlation; ** $p < 0.01$ indicates a significant correlation; *** $p < 0.001$ indicates a highly significant correlation.

TABLE 4. Results of the Discriminant Validity Test of the Critical Thinking Quality Scale

	Truth-seeking	Open-mindedness	Analyticity	Systematicity	Confidence	Inquisitiveness	Maturity
Truth-seeking	0.516						
Open-mindedness	0.636	0.511					
Analyticity	-0.034	-0.135	0.543				
Systematicity	0.041	0.066	0.251	0.524			
Confidence	0.121	0.215	0.232	0.571	0.527		
Inquisitiveness	0.065	0.013	0.226	0.38	0.454	0.526	
Maturity	0.469	0.571	-0.087	0.104	0.18	0.019	0.527
AVE Square Root	0.718	0.715	0.7	0.724	0.726	0.722	0.726

TABLE 5. Hypothesis Testing Results of Path Relationships in the SEM Model of Critical Thinking Qualities

Assuming Path	Unstandardized Estimation	Standard Error (SE)	Critical Ratio (CR)	p-value
Truth-seeking → Critical Thinking Quality	1.943	.267	7.278	***
Open-mindedness → Critical Thinking Quality	.809	.247	3.270	.001
Analyticity → Critical Thinking Quality	1.589	.289	5.494	***
Systematicity → Critical Thinking Quality	-1.633	.585	-2.792	.005
Self-confidence → Critical Thinking Quality	2.374	.552	4.304	***
Inquisitiveness → Critical Thinking Quality	1.722	.332	5.194	***
Maturity → Critical Thinking Quality	2.149	.331	6.485	***

Note: *** indicates $p < 0.001$.

school students to the objective world is primal, pragmatic, as it is in the formative stage of their worldview. This attitude is revealed in English learning through respect towards linguistic facts, seeking correct understanding and not being blinded by authority. Maturity, however, is manifested in the capacity to withhold judgment, to take into account numerous possibilities and to be thoroughly aware of the complexity and uncertainty underlying linguistic phenomena. The teaching of English should lead students to analyze language using facts and evidence, where they should critically assess the multiple meanings of texts, and not seek simplistic solutions (either-or). Third, the positive impact of analyticity, inquisitiveness and open-mindedness demonstrate the cognitive abilities and affective disposition

TABLE 6. The Influence of Each Dimension on Critical Thinking Quality

Influence Path	Direct Effects	Indirect Effects	Total Effect
Truth-seeking → Critical Thinking Quality	0.415	0	0.415
Open-mindedness → Critical Thinking Quality	0.178	0	0.178
Analyticity → Critical Thinking Quality	0.243	0	0.243
Systematicity → Critical Thinking Quality	0.257	0	0.257
Self-confidence → Critical Thinking Quality	0.476	0	0.476
Inquisitiveness → Critical Thinking Quality	0.278	0	0.278
Maturity → Critical Thinking Quality	0.386	0	0.386

that enable students to think critically; analyticity focuses on the students to deconstruct and reason language material logically; inquisitiveness motivates them to actively investigate the rule and cultural connotation underlying language phenomena; and open-mindedness encourages them to accept other points of view and expression. These three are the working basis of development of critical thinking.

The most interesting point that can be discussed in detail is the adverse effect of the systematicity dimension. This finding, though it may sound counter-intuitive, can be described in the context of the English learning in high school. The dimension of systematicity in the scale applied in this research highlights the logical, sequential and organized thinking. Traditional teaching of English in high school usually focuses on systematicity, structure, and sequences, e.g. learning grammar rules systematically and writing based on pre-existing templates. Such a heavy emphasis on systematicity can conflict with critical thinking process that prompts divergent thinking, questioning existing structures, and making non-linear and inventive connections. In high school students undergoing the process of knowledge construction and rule reconstruction, a too rigid or linear thinking pattern of what is referred to as systematicity can to some degree prevent the emergence of flexibility, innovation and deep associative skills in the critical thinking qualities of high school students.

V. CONCLUSION

This study, grounded in cognitive motivation theory, uses structural equation modeling to empirically explore the internal structure and development of critical thinking qualities in high school English learners within the specialized context of engineering and fiber science. The study found that critical thinking qualities are a multi-dimensional construct consisting of seven dimensions: truth-seeking, open-mindedness, analyticity, systematicity, self-confidence, inquisitiveness, and maturity. Among these, self-confidence, truth-seeking, and maturity are the most critical affective and cognitive foundations influencing overall quality development; analyticity, inquisitiveness, and open-mindedness are important process-oriented abilities and tendencies; while systematicity exhibits a unique inhibitory effect in the context of this study. Based on the relationship between cognition and behavior, these seven dimensions can be divided into three categories: the first category belongs to the cognitive dynamics of critical thinking qualities (truth-seeking, inquisitiveness, and maturity); the second category belongs to its psychological support (self-confidence); and the third category belongs to its operational characteristics (open-mindedness, analyticity, and systematicity). Based on the internal-external dichotomy of motivational attributes, they can also be divided into internal motivation (truth-seeking, analyticity, inquisitiveness, and maturity) and external motivation (open-mindedness, systematicity, and self-confidence).

AUTHOR CONTRIBUTIONS

Yilong Chen designed, collected and analyzed the data, and drafted the manuscript. Yilong Chen conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Yilong Chen participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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HUMAN RESEARCH SUBJECTS

This study was approved by the Ethics Committee of Guangdong Industry Polytechnic University, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

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