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Email: tapchikhoahoc@hcmue.edu.vn; Website: http://tckh.hcmue.edu.vn

MODEL FOR THE BUILDING OF THE ASSESSMENT SCALE TO EVALUATE HIGH SCHOOL STUDENTS' CRITICAL THINKING COMPETENCE IN CHEMISTRY

Trinh Le Hong Phuong*

Ho Chi Minh City University of Education

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ABSTRACT

Developing students' critical thinking competence in Chemistry is one of the most effectual solutions to help the students gain insights into the nature of chemical objects. This article introduces the assessment scale of evaluating students' critical thinking competence in chemistry in accordance to reasoning about definitions, structures, levels of manifestation of critical thinking. The five principles and five steps of the procedure are also strictly followed.

Keywords: assessment scale for competence, competence, critical thinking competence.

TÓM TẮT

Mô hình xây dựng thang đo đánh giá năng lực tư duy phê phán trong Hóa học của học sinh trung học

Việc phát triển năng lực tư duy phê phán hóa học (TDPPHH) là một trong những giải pháp tối ưu giúp học sinh có cái nhìn chính xác, sâu rộng về bản chất của các đối tượng hóa học. Bài báo này giới thiệu thang đánh giá năng lực TDPPHH cho học sinh dựa trên cơ sở lí luận về khái niệm, cấu trúc, mức độ biểu hiện của năng lực TDPPHH và tuân theo 5 nguyên tắc, 5 bước của quy trình xây dựng thang đánh giá năng lực.

Từ khóa: thang đánh giá năng lực, năng lực, năng lực tư duy phê phán.

1. Introduction

Chemistry is an experimental science in which all theories, laws, concepts, conception, and so forth stem from practical phenomena, experiments and manufacturing processes. Therefore, learners must have such skills as observing, analyzing, evaluating, predicting as well as applying the knowledge to come to precise and rational results with the purpose of acquiring and studying Chemistry. Promoting students' critical thinking competence in Chemistry is one of the most optimal solutions to help the students gain a deeper insight into the nature of chemical objects.

* Email: *phuongsphoa@gmail.com*

In accordance to the mentioned reasons and demands for new educational strategies regarding development of the learners' comprehensive competence and virtues stated in Resolution 29 from session 11 of the 8th Central Executive Committee Assembly, we assume that building the grading scale of evaluating high school students 'critical thinking competence in chemistry is of true importance.

2. Solutions

2.1. An overview of critical thinking competence in chemistry

2.1.1. A concept of "critical thinking competence in chemistry"

Ms Tran (2010), once said: "Critical thinking is humans' ability to evaluate, representing their positive interaction with the world" (p.435). According to such basis along with typical features of a subject, we considered: "Critical thinking competence in Chemistry is an competence to carry out mental practices including analysis, synthesis, comparison, generalization as well as abstraction with a view to giving out comments, conclusion and the most optimal solution towards obstacles arising from learning – researching courses of Chemistry." This is a skill that requires not only the intense level of mental practice but is also a foundation for students' self-study in higher education.

2.1.2. The structure of "critical thinking competence in chemistry"

According to the concept of "critical thinking competence in chemistry", Chemistry curriculum of high school, results from analyzing and synthesizing evaluation forms of 56 post-graduates in "Reasoning and Teaching Methodology of Chemistry" course 23rd (2013 – 2015); course 24th (2014 – 2016) at Ho Chi Minh City University of Education as well as 15 experts in "The Theory and Teaching Methodology of Chemistry" at Ha Noi University of Education, HCMC University of Education, Hue University of Education, we have come up with the structure of "critical thinking competence in chemistry" as following.

If we approach the Chemistry curricular depending on **the learning output** (also known as an approach on tending to develop learner's competence), critical thinking competence in chemistry will include the competency in analyzing chemical cases, the competency in evaluating chemical cases as well as the competency in solving chemical cases. We call this "Systematic Structure" of critical thinking competence in chemistry. To be more specific,

The competency in analyzing chemical cases: this competency helps to identify the basic relationship between objects in a variety of chemical cases using knowledge of all learning subjects.

The competency in evaluating chemical cases: this competency helps to protect one's viewpoints or perspectives using scientific evidences, from which we can draw valuable conclusions from examining such chemical cases.

The competencey in solving chemical cases: this competency helps to identify and creatively carry out solutions to reduce existing shortcomings inside chemical cases.

2.1.3. The manifestation of critical thinking competence in Chemistry

According to the basis of determining the structures of critical thinking competence in Chemistry, the psychophysiological features of high school students, high school Chemistry curriculum together with employing specialized methodology, we have defined several kinds of manifestation as following.

Table 1. *Kinds of manifestation of critical thinking competence in Chemistry*

The component competences	Manifestation
Chemical Analyzing Competence	1- Figuring out processing rules inside chemical cases. 2- Making questions regarding the examining cases. 3- Giving explanation on chemical cases.
Chemical Evaluating Competence	4- Determining the drawbacks needed to be solved. 5- Protecting your own viewpoints or perspectives. 6- Drawing conclusion on the examining cases.
Chemical Solving Competence	7- Proposing different scientific hypotheses. 8- Building up solving plans. 9- Carrying out the plans independently and creatively. 10- Self-adjusting plans in case of unsuccessful solutions.

2.2. The assessment scale of evaluating high school students' critical thinking competence in chemistry

2.2.1. The purposes of building the assessment scale of evaluating high school students' critical thinking competence in Chemistry

With a view to having precise and objective evaluation, these following objectives need to be taken into consideration when building the grading scale.

a. To teachers

- Determining the teaching objectives that need to be acquired at the end of each lesson stage.

- Drawing accurate, sufficient conclusion and judgment on students' development of critical thinking competence in Chemistry.

- Identifying opportunely students' efforts and progresses, from which the teachers are capable of giving support, encouragement and instructions for their overcoming difficulties while studying.

- Proposing suitable promoting measures for each type of high school students.

b. To students

The assessment scale can be regarded as an intensive supporting tools for students in such aspects as following.

- Self-assessing or evaluating own critical thinking competence in Chemistry based on the levels of manifestation represented in the assessment scale.

- Figuring out the differences between their own competence and the teacher's requirements, from which the students can take specific actions to improve themselves.

- Orienting and adjusting subjectively behavioral actions during the course.

2.2.2. The principle of building the assessment scale of critical thinking competence in Chemistry

We have given out several principles with the purpose of giving an instruction on building the assessment scale of critical thinking competence in Chemistry:

Principle 1: Assuring systematic and scientific characteristics

This is a general and compulsory principle for all levels of high school students. Therefore, the structure of the assessment scale for the representation levels in critical thinking competence in Chemistry must be logical, precise and the relations among the component competences must be sensible.

Principle 2: Assuring objective characteristics

An accurate and objective evaluation will help satisfy the students' mind, stimulate the learning spirit positively, reinforce the prestige and love from students to their teachers. Hence, some key points should be considering so as to assure the objective characteristics when building the grading scale of critical thinking competence in Chemistry.

- The structure of the scale must be precise and the criterias for evaluation must thoroughly present the development of critical thinking competence in Chemistry.

- The objectives of high school Chemistry curricular must be strictly followed in order to build up the evaluating criterias.
- The written language in the grading scale must be comprehensible and scientifically accurate.

Principle 3: Assuring pedagogical characteristics

This principle requires choosing the criterias which are suitable for the high school students' psychological features and awareness. According to this, the evaluating criterias need to be dispersed and arranged orderly from simple to complex, specific to general and even more than that.

Principle 4: Assuring practical characteristics

This principle requests that an act of building the grading scale of critical thinking competence in Chemistry must be orginated from searching, analyzing and evaluating the reality of teaching Chemistry in high schools. Besides, the criterias that we are working on are always stemmed from recent demands, principles, assessing processes in Chemistry of the high school students.

Principle 5: Assuring diversifying and comprehensive characteristics

A variety of criteria will help the students' formation and development of critical thinking competence in Chemistry achieve great efficiency. We have employed the systematic – structural standpoint into the making of the grading scale for the representation levels in critical thinking competence in Chemistry, which means three to four criterias will value one component competence of critical thinking competence in Chemistry. All the criterias in the scale always have a close relationship with each other and they play a significant role in evaluating the high school students' critical thinking competence in Chemistry profoundly.

2.2.3. The process of building the assessment scale of critical thinking competence in Chemistry

Step 1: Researching materials:

- Collecting, studying the materials regarding an issue of evaluating competence and critical thinking competence in Chemistry of the students.
- Studying the high school Chemistry curriculum.

Step 2: Outlining the assessment scale to the high school students:

We have outlined the grading scale to the high school students based on the reasoning basis of the study, the objectives as well as the principles when building the scale.

Step 3: Asking for advice from experts with a view to having an initial edition to the assessment scale

- Using a questionaire to survey in consultation with the high school Chemistry teachers, the experts in Reasoning and Teaching Methodology of Chemistry about the scale.

Table 2. *A list of the surveyed schools*

Number	Schools name – province, city	The number of questionnaires delivered	The number of questionnaires retrieved
1	Le Hong Phong High School For The Gifted, HCMC	13	10
2	Tran Dai Nghia High School For The Gifted, HCMC	14	12
3	High School For The Gifted, HCMC National University	16	10
4	Thoai Ngoc Hau High School, An Giang Province	11	11
5	Thu Khoa Nghia High School, An Giang Province	10	8
6	Le Quy Don High School, Da Nang City	9	9
7	Ly Tu Trong High School, Can Tho City	12	10
8	Hue National High School For The Gifted, Hue City	12	10
9	High School For The Gifted - Hue University of Science, Hue City	8	8
10	Bac Quang Nam High School, Quang Nam Province	10	8
11	Nguyen Binh Khiem High School, Vinh Long Province	9	9
12	Le Khiet High School For The Gifted, Quang Ngai Province	8	7
13	Le Quy Don High School For The Gifted, Binh Dinh Province	7	6
14	Luong Van Chanh High School For The Gifted, Phu Yen Province	11	10
15	Le Quy Don High School For The Gifted,	8	8

	Khanh Hoa Province		
16	Le Quy Don High School, Ninh Thuan Province	6	6
17	Phan Boi Chau High School, Binh Thuan Province	7	6
18	Thang Long High School For The Gifted, Da Lat City	10	8
19	Nguyen Du High School, Dak Lak Province	10	9
20	Hung Vuong High School For The Gifted, Gia Lai Province	11	11
21	Nguyen Tat Thanh High School, Kon Tum Province	8	8
22	Luong The Vinh High School For The Gifted, Dong Nai Province	11	10
23	Nguyen Hue High School, Ba Ria - Vung Tau City	10	10
24	Ben Tre High School For The Gifted, Ben Tre Province	10	9
25	Quang Trung High School For The Gifted, Binh Phuoc Province	6	6
26	Tien Giang High School, Tien Giang Province	8	8
27	Vi Thanh High School For The Gifted, Hau Giang Province	6	6
28	Bac Lieu High School For The Gifted, Bac Lieu Province	13	12
29	Phan Ngoc Hien High School For The Gifted, Ca Mau Province	6	6
30	Hung Vuong High School For The Gifted, Binh Duong City	10	9
31	Huynh Man Dat High School For The Gifted, Kien Giang Province	6	6
32	Nguyen Binh Khiem High School For The Gifted, Vinh Long Province	12	10
33	Tra Vinh High School For The Gifted, Tra Vinh Province	5	5

34	Hoang Le Kha High School For The Gifted, Tay Ninh Province	8	8
35	Nguyen Thi Minh Khai High School For The Gifted, Soc Trang Province	8	8
36	Nguyen Quang Dieu High School For The Gifted, Dong Thap Province	7	7
37	Nguyen Dinh Chieu High School For The Gifted, Dong Thap Province	9	9
38	Long An High School For The Gifted, Long An Province	5	5
	Total	**350**	**318**

Table 3. *A list of the surveyed experts in Reasoning and Teaching Methodology in Chemistry about the grading scale of critical thinking competence in Chemistry*

Number	Full name	Role
1	Bieu Trinh Van	Providing feedbacks for the building, editing, and completing the assessment scale to evaluate the students' critical thinking competence in chemistry
2	Lan Trang Thi	
3	Bien Nguyen Cao	
4	Dung Le Thi Kim	
5	Ha Dang Viet	
6	Ha Nguyen Thi Thu	
7	Ha Thai Hai	
8	Lieu Nguyen Thi	
9	Linh Pham Ngoc Thuy	
10	Linh Nguyen Thi Thuy	
11	Linh Van Thi Ngoc	
12	Mai Do Thanh	
13	Loan Do Hong	Performing the experiments for the assessment scale in the teaching of chemistry in high school
14	Nhung Nguyen Thi Tuyet	
15	Hang Le Trung Thu	
16	Oanh Vu Thi Kim	
17	Tam Tran Thi Thanh	
19	Thach Nguyen Vu Cam	

20	Thao Nguyen Phuong
21	Thao Nguyen Thi Bich
21	Thao Tran Thi Phuong
22	Thuy Pham Ngoc
23	Tong Nguyen Thi
24	Tram Dang Ngoc
25	Tran Ngo Huyen
26	Uyen Nguyen Hoang
27	Van Ha Tu
28	Vinh Nguyen Van
29	Vinh Phan Thi
30	Xuan Nguyen Thi Ngoc

- Using the statistical method in Mathematics to draw the conclusions with scientific values, from which changes in the grading scale of critical thinking competence in Chemistry are made (if necessary) according to the experts' suggestions.

Step 4: Experimenting with the assessment scale in teaching and learning Chemistry in high schools

We carried out the experiments on the grading scale in teaching and learning Chemistry in 15 high schools in Dong Nai Province, Long An Province and Ho Chi Minh City. After that we drew the conclusion for the final edition.

Table 4*. A list of high schools performing experiments on the assessment scale of critical thinking competence in Chemistry*

Number	High School	Province - City
1	Ngo Quyen	
2	Thong Nhat A	
3	Long Thanh	Dong Nai Province
4	Nhon Trach	
5	Tan Phu	
6	Le Qui Don	
7	Tan Tru	Long An Province
8	Thu Thua	

9	Can Duoc	
10	Rach Kien	
11	Bui Thi Xuan	
12	Nguyen Thi Minh Khai	
13	Tran Khai Nguyen	Ho Chi Minh City
14	Nguyen Chi Thanh	
15	Marie Curie	

Step 5: Editing and improving the grading scale of competence levels in Chemistry critical thinking

After doing several experiments in high schools, we edited, complemented and improved the grading scale of representation levels in critical thinking competence in Chemistry for the purpose of assuring the efficiency and the possibility of such scale.

2.3. The assessment scale of critical thinking competence in Chemistry for high school students

According to the reasoning basis, scientific basis together with the teaching objectives in high school Chemistry curriculum and the objectives in promoting the component competences in the Systematic Structure of critical thinking competence in Chemistry, we have formed the tools and the grading scale of critical thinking competence in Chemistry for high school students as following.

Table 5. *A table of evaluating critical thinking* competence *in Chemistry for high school students(0:not presented; 1: rarely presented; 2: sometimes presented; 3:always presented)*

The component competences	**The representation of critical thinking competence in Chemistry**	**The marking levels**			
		0	**1**	**2**	**3**
Chemical Analyzing Competence	Identifying exactly and adequately the relationship among the chemical objects.				
	Making questions in order to search for the whole nature of chemical objects.				
	Giving adequate and appropriate explanation on the given questions				
Chemical Evaluating	Determining exactly and adequately the shortcomings that need to be overcome.				

Competence	Using scientific evidences to protect your own viewpoints.
	Drawing appropriate conclusion on the examining cases.
	Suggesting more new and feasible scientific hypotheses.
Chemical Solving Competence	Making detailed plans for conducting the optimal measures.
	Conducting the measures independently and creatively.
	Self – adjusting the plans creatively to be suitable for real conditions.
Total	

According to the evaluating plan above, we have drawn the conclusions on the students' critical thinking competence in Chemistry, equalling to such marks as following.

Table 6. *Evaluating scale of the high school students' critical thinking competence in Chemistry*

Mark	Conclusion
0 -5	No critical thinking practices are made to solve chemical cases.
6 – 14	The critical thinking practices are made to solve easy chemical cases.
15 – 23	The critical thinking practices are proficiently made to solve complex chemical cases but low creativity.
24 – 30	The critical thinking practices are proficiently made to flexibly solve almost chemical cases requiring a high level of creativity.

3. Conclusion

Thanks to the research, we assume that the making of the grading scale of critical thinking competence in Chemistry is indispensable, which greatly contributes to the enhancement on Chemistry teaching qualification in high schools since this scale offers a significant advantage in supporting the teachers as well as the students with their orientation for specific activities so as to acquire the objectives determined during the courses of Chemistry. Besides, it is a tool for evaluating and self-evaluating process in accordance with the teaching of promoting competence – orientation.

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