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Validity and Reliability of Science Critical Thinking Learning Model to Improve Critical Thinking Skills and Self-Efficacy of Chemistry Teacher Candidates

Rusmansyah
Universitas Lambung Mangkurat
Banjarmasin. Indonesia
rusmansyah_kimia@unlam.ac.id

Leny Yuanita
Universitas Negeri Surabaya
Surabaya, Indonesia

Muslimin Ibrahim
Universitas Negeri Surabaya
Surabaya, Indonesia

Binar Kurnia Prahani
Universitas Negeri Surabaya
Surabaya, Indonesia

Isnawati
SMPN 6 Banjarmasin
Banjarmasin, Indonesia

***Abstract*—The Science Critical Thinking (SCT) learning model is a science process skill-based chemistry learning that is used in chemistry learning to improve critical thinking skill and self-efficacy of chemistry teacher candidates. The purpose of this study is to analyse the validity and reliability of SCT Learning Model that has been developed to improve critical thinking skill and self-efficacy of chemistry teacher candidates. SCT learning model syntax covers: 1) problem orientation; 2) scientific activity; 3) presentation of scientific activity result; 4) critical thinking task completion; and 5) evaluation. The data validity and reliability of SCT Learning Model was obtained through Focus Group Discussion (FGD) activity. In order to analyse the validity and reliability of the SCT Learning Model, researchers used single-action interrater coefficient correlation (ICC) and Cronbach's coefficient alpha. The results showed that the SCT Learning Model has fulfilled the validity requirements (rα = .87) and reliability (α = .98), so the SCT Learning Model meets the validity and reliability requirements. The implications of this study are that the valid and reliable SCT Learning Models can be used theoretically to improve critical thinking skill and self-efficacy of chemistry teacher candidates. Further research can be conducted to test the practicality and effectiveness of the SCT Learning Model to improve critical thinking skill and self-efficacy of chemistry teacher candidates.**

***Keywords*—Validity, reliability, critical thinking skills, self-efficacy, chemistry teacher candidates**

I. INTRODUCTION

The 21st century skills became a basic need in facing the industrial revolution 4.0. One of the 21st century skills that must be owned by chemistry teacher candidates is critical thinking skill. Critical thinking skill is an essential for a chemistry teacher candidate based on the results of the study [1-4] which showed that learning and assessment of critical thinking skill are indispensable and driven by the needs of students at the college level and work environment. Therefore, educators are required to improve the critical thinking skill of chemistry teacher candidates in Indonesia. Chemistry teacher candidates must have not only the critical thinking skill but also high self-efficacy to compete in the industrial revolution 4.0.

The results showed that self-efficacy has a direct positive effect on students' scientific attitudes toward chemistry [5]. Positive self-efficacy is closely related to motivation, learning behaviour, future general expectations and learners' performance [6]. The results of the study showed how important the self-efficacy is to be trained and owned by chemistry teacher candidates in Indonesia. Therefore, it is clear that specific by design innovative chemistry learning models can improve critical thinking skills and self-efficacy of chemistry teacher candidates.

The SCT Learning Model is a science process skill-based chemistry learning that is used to improve critical thinking skill and self-efficacy of chemistry teacher candidates. In a previous study, hypothetical Science Critical Thinking (SCT) Learning Model had been developed based on innovations from Problem Based Learning (PBL) and Inquiry models that were specifically developed to improve critical thinking skills and self-efficacy of chemistry teacher candidates. SCT Learning Model that has been developed is expected to improve critical thinking skill and self-efficacy that refers to the flow of problem-solving process from Dewey.

The product criteria (mode) that is developed should be eligible to be valid, practical, and effective [7]. This also applies to the SCT Learning Model that has been developed to improve critical thinking skill and self-efficacy of chemistry teacher candidates to be feasible by meeting the aspects of validity, practicality and effectiveness. This research is the first step in fulfilling the feasibility aspect of SCT learning model that is developed, that is the fulfilment of validity aspect. The validity aspects of SCT Learning Model were reviewed based on the content validity, construct validity, and reliability. After the SCT Learning Model has been declared to be valid and reliable, theoretically it can be used to test the practicality and effectiveness of SCT learning model to improve critical thinking skill and self-efficacy of chemistry teacher candidates. Therefore, this study focused to analyse the validity and reliability of SCT Learning Model

in improving critical thinking skill and self-efficacy of chemistry teacher candidates.

The rest of this paper is organized as follow: Section II describes proposed research method. Section III presents the obtained results and following by discussion in Section IV. Finally, Section V concludes this work.

II. PROPOSED METHOD

The validity of SCT Learning Model is assessed based on the content validity and construct validity. According to Nieveen, *et* al. in [8] that the validity is divided into two, they are the content validity and the construct validity. Content validity is there is a need for the intervention and its design is based on state-of-the-art (scientific) knowledge [8-9]. The assessment of content validity in terms of some aspects in the assessment is as follows: 1) The SCT Learning Model Development Needs; 2) State of the art of knowledge; 3) Thinking Framework of the SCT Learning Model Formation; and 4) Description of the SCT Learning Model [8-11]. Construct validity (construct validity) is the intervention is 'logically' designed [8,9].

The assessment of the construct validity is reviewed from several aspects as follows: 1) Consistency of SCT Learning Model Development; 2) Thinking Framework of the SCT Learning Model Formation; and 3) Description of the SCT Learning Model [8-11]. The developed SCT Learning Model is validated by 2 experts in Focus Group Discussion (FGD). Focus Group Discussion (FGD) is a small group discussion in which participants respond to a series of questions focused on a single topic [9]. Experts in the FGD consisted of 1 chemistry professor and 1 doctor of chemistry education. The FGD was held for 2 hours. Before the FGD, the experts were given the SCT Learning Model Book and the SCT Learning Model Validation Sheet 2 weeks earlier. The SCT Learning Model Validation Sheet was filled by experts who reviewed and assessed the learning model developed by researchers during Focus Group Discussion (FGD). The SCT Learning Model Validation Sheet is used to obtain validity and reliability data of the SCT Learning Model. The SCT Learning Model Validation Sheet consists of: 1) the content validation sheet of SCT Learning Model, 2) the construct validation sheet of SCT Learning Model. FGD results were served as a reference to revise the SCT Learning Model. The validity of the SCT Learning Model is determined based on the validity criteria that is presented in Table I. Further analysis to strengthen the validity and reliability of SCT Learning Model used single interrater coefficient correlation (ICC) and Cronbach's coefficient alpha. The validity and reliability of SCT Learning Model is determined by the validity formula as follow:

r_α= [(Mean Square people–Mean Square residual)/(Mean Square people + (k–1) ∗Mean Square residual)]

and

Cronbach's alpha $\alpha = k\, r_\alpha/[1+(k-1)\, r_\alpha]$ [12-13].

The SCT Learning Model is valid if $r_\alpha > r_{\text{table}}$ and invalid if $r_\alpha \leq r_{\text{table}}$.

III. RESULTS

The content and construct validation results of the SCT Learning Model are presented in Table I. Table I shows that the content validity of the SCT Learning Model includes: 1) The SCT Learning Model Development Needs; 2) State of the art of knowledge; 3) Thinking Framework of the SCT Learning Model Formation; and 4) Description of the SCT Learning Model, all of them have a minimum value of .87 and is greater than r table (.16), so that each component is valid. While for the reliability of each component in terms of the αvalue, all of them are all between the values of .98 and .99, so that each component is declared reliable.

TABLE I. THE VALIDITY AND RELIABILITY OF THE SCT LEARNING MODEL.

Components	Validity and reliability of the SCT Learning Model			
Content Validity	r_α	Validity	α	Reliability
1. The SCT Learning Model Development Needs	.89	Valid	.98	Reliable
2. State of the art	.90	Valid	.99	Reliable
3. Thinking Framework of SCT Learning Model Formation	.88	Valid	.98	Reliable
4. Description of SCT Learning Model	.87	Valid	.98	Reliable
Construct Validity				
1. Consistency of SCT Learning Model Development	.88	Valid	.97	Reliable
2. Thinking Framework of SCT Learning Model Formation	.89	Valid	.99	Reliable
3. Description of SCT Learning Model	.87	Valid	.98	Reliable

In addition to the FGD process, the validators provide suggestions to improve the quality of SCT Learning Model. Suggestions from validators are used as reference for the revision process of SCT

Learning Model in order to be able to be implemented. Table I shows that the construct validity of the SCT Learning Model includes: 1) Consistency of SCT Learning Model Development; 2) Thinking Framework of the SCT Learning Model Formation; and 3) Description of the SCT Learning Model, all of them have a minimum value of .87 and is greater than *r* table (.16), so that each component is valid. While for the reliability of each component in terms of the α value, all of them are between the values of .97 and .99, so that each component is declared reliable.

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to be implemented. Syntax of the SCT Learning Model presented in Table II.

TABLE II. SYNTAX OF THE SCT LEARNING MODEL.

Lecturer Activities	Activities of Chemistry Teachers Candidates
Phase 1: Orientation of Chemistry Teachers Candidates 1. Lecturer conveys the learning objectives, provides instructional direction, and assesses critical thinking skills and self-efficacy. 2. Lecturers divide students into heterogeneous groups (3-4 students) and divide the chemistry worksheet.	1. Chemistry teacher candidates pay attention to the purpose of learning, direction about learning, and assessment of critical thinking skills and self-efficacy delivered by lecturers. 2. Chemistry teacher candidates form heterogeneous groups (3-4 students) and receive chemistry worksheet provided by lecturers.
Phase 2: Scientific Activities Lecturer guides chemistry teacher candidates to carry out experiments as an effort to train critical thinking skills and instill self-efficacy.	Chemistry teacher candidates carry out experiments to train critical thinking skills and instill self-efficacy.
Phase 3: Presentation of Scientific Activities Results 1. Lecturer guides chemistry teacher candidates to present / communicate the results of scientific activities to classical / to other groups. 2. Lecturer guides the chemistry teacher candidates to internalize the concept, critical thinking skills and self-efficacy of the students through the presentation activities.	1. Chemistry teacher candidates present / communicate the results of scientific activities to classical / to other groups. 2. Chemistry teacher candidates internalize their concept, critical thinking skills and self-efficacy through presentation activities.
Phase 4: Completion of Critical Thinking Tasks Lecturers provide follow-up tasks in the form of critical thinking tasks that must be solved individually as a stage to improve the critical thinking skills that they already have and improve self-efficacy of chemistry teacher candidates.	Chemistry teacher candidates undertake follow-up tasks in the form of critical thinking tasks that must be solved individually as a stage of improving the critical thinking skills they have and improving self-efficacy of chemistry teacher candidates.
Phase 5: Evaluation Lecturer guides chemistry teacher candidates to evaluate the process and outcomes in the completion of the critical thinking task and self-efficacy.	Chemistry teacher candidates evaluate processes and outcomes in the completion of their critical thinking task and self-efficacy.

IV. DISCUSSION

The hypothetical SCT Learning Model that was developed had been validated by 2 experts in FGD. Experts in the FGD consisted of 1 chemistry professor and 1 doctor of chemistry education. The discussion of Table I on the content validity of the SCT Learning Model is described as follows. The content validity focuses there is a need for the intervention and its design is based on state-of-the-art (scientific) knowledge [8,9]. The aspects SCT Learning Model Development Needs includes: 1) The importance of developing SCT learning model to meet the needs of 21st century competency framework as written in partnership for 21st century skills; 2) SCT learning model can meet the needs of 21st century skills-based research trends, that is critical thinking skill and self-efficacy to be successful in today's and future life. 3) SCT learning model meets the demands of the times according to KKNI Curriculum. 4) The benefits of the SCT learning model refer to meet the needs of critical thinking skill and self-efficacy to be successful in todays and future life. 5) The purpose of the SCT learning model refers to meet the needs of critical thinking skill and self-efficacy to be successful in todays and future life.

The aspects of Advance Knowledge of The SCT learning model includes: 1) SCT learning model is built to meet the state of the art of knowledge by improving the weaknesses based on the recommendations of existing researchers: a) PBL model: [2,14-22]. b) The Inquiry Model: [5,23-24]. 2) Using the theoretical foundations of educational psychology figures listed in standard books [10,25-27].

Thinking Framework of SCT Learning Model Formation includes: 1) Study of standard reference literatures that meets the state of the art aspects of chemistry learning in Higher Education. 2) Study of standard reference literatures that meet the state of the art aspects of critical thinking skill. 3) Study of standard reference literatures that meet the state of the art aspect of self-efficacy. 4) Study of standard reference literatures that meet the state of the art aspects of the PBL and Inquiry learning models in improving critical thinking skill and self-efficacy. 5) The development of the SCT Learning Model is supported by the theory: Constructivism socio-cognitive theories, cognitive theories of learning, behavioural theories of learning, and motivation theories of learning, and supported by empirical foundations and reference standards on the need for innovative learning model to improve critical thinking skill and self-efficacy.

Description of SCT Learning Model includes: 1) Characteristics of Learning Model includes: a) Purpose of SCT Learning Model; b) Model Stages and Arguments; Syntax Planning; c) Implementation of the Social System; Application of Reaction Principles; Support System; d) as well as the Instructive and Companion Impacts. 2) Classroom Learning and Environment Management based on the standard reference that meets the state of the art aspect. 3). Evaluation Implementation: Critical Thinking Skill and self-efficacy based on standard references that meet the state of the art aspect. The results of this study showed that the SCT Learning Model's content has been valid to improve critical thinking skills and self-efficacy of chemistry teacher candidates.

The discussion of Table I on the construct validity of the SCT Learning Model is described as follows. Construct Validity focuses on the intervention is 'logically' designed [8,9]. Consistency of SCT Learning Model Development includes: 1) the development of SCT learning model with 21st century competency framework as written in Partnership for 21st century skills is designed logically. 2) The suitability of SCT learning model with the need of 21st century skill-based research trend that is critical thinking skill and self-efficacy to be successful in present and future life is logically designed. 3) The suitability of SCT learning model with the demands of the age according to KKNI Curriculum is logically designed. 4) The conformity between the rational importance of model development, model

development goals, and the benefits of model development are logically designed.

Thinking Framework of SCT Learning Model Formation includes: 1) Study of standard reference literatures that meet the logical aspects of chemistry learning in Higher Education. 2) The study of standard reference literatures that meet the logical aspects of critical thinking skill. 3) Study of standard reference literatures that meet the logical aspects of self-efficacy. 4) Study of standard reference literatures that meet the logical aspects of the PBL and Inquiry learning models in improving critical thinking skill and self-efficacy. 5) The consistency between theoretical support and empirical support for the development of the SCT Learning Model (Supported by the theory: Constructivism socio-cognitive theories, cognitive theories of learning, behavioural theories of learning, and motivation theories of learning, and supported by the empirical foundations and reference standards need for innovative learning models to improve critical thinking skill and self-efficacy). 6) SCT learning model is built consistently and logically to improve the weaknesses based on the recommendations of existing researchers, they are: a) PBL model: [2,14-22]. b) The Inquiry Model: [5,23-24]. 7) The SCT learning model was built on the theory of educational psychology figures listed in standard books [10,25-27] and was logically designed.

Description of SCT Learning Model includes: 1) Characteristics of learning model that is consistently and logically designed includes: a) Purpose of SCT Learning Model; b) Model Stages and Arguments; Syntax Planning; c) Implementation of the Social System; Application of Reaction Principles; Support System; d) as well as the Instructive and Companion Impacts. 2) Learning Environment and Classroom Management that was developed was designed logically. 3) Implementation of Evaluation: Critical thinking Skill and self-efficacy are developed and designed logically. The results of this study supported the results of previous research that innovative learning models must fulfil the valid criteria can be implemented to find the practicality and effectiveness of learning models developed [28.29]. The valid learning models and materials can be implemented to see the effectiveness and effectiveness of developed learning models and materials [29-34]. The need for chemistry learning that can improve self-efficacy, critical thinking, and learning outcomes and prevent misconceptions [35-36]. The results of this study prove that the SCT Learning Model has been constructively valid to improve critical thinking skill and self-efficacy of chemistry teacher candidates. Theoretically and the results of validation by experts through FGD prove that the construct and content of SCT Learning Model has been valid and reliable to improve critical thinking skill and self-efficacy of chemistry teacher candidates.

V. CONCLUSION

SCT learning model syntax covers: 1) orientation of Chemistry Teachers Candidates; 2) scientific activity; 3) presentation of scientific activity result; 4) critical thinking task completion; and 5) evaluation. The results of the study showed that the SCT Learning Model has fulfilled the validity requirements (rα .87) and reliability (α = 1.00), so that the SCT Learning Model to improve critical thinking skill and self-efficacy of chemistry teacher candidates has qualified the validity and reliability. The implications of this study are that the valid and reliable SCT Learning Model can be used theoretically to improve critical thinking skill and self-efficacy of chemistry teacher candidates. Further research can be conducted to test the practicality and effectiveness of the SCT Learning Model to improve critical thinking skill and self-efficacy of chemistry teacher candidates.

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