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Consistency and Relevance of Structured Lecture Materials in Physical Chemistry 3 Subjects

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***Abstract*. The purpose of the study was to produce a Physical Chemistry 3 (PC3) Structured Lecture Material (SLM-PC3) that was feasible to facilitate students to achieve the minimum ability in argumentation skills (AS), science process skills (SPS), and problem solving skills (PSS) as part of the thinking ability of 21st century demands This development research follows the design of ADDIE (Analysis, Design, Develop, Implementation, and Evaluate). The eligibility criteria refer to Nieveen and Plomp (2013) recommendations, namely validity, practicality, and effectiveness. This article presents the results of (SLM-PC3) validation in terms of consistency (construct validity) and relevance (content validity). The construct validation is assessed based on the development design, which is the indicator of AS, SPS and PSS. Content validity is assessed based on the absence of conceptual errors in the substance of the SLM builder. Data construct validity and content validity are the results of the assessment of three experts in the field of chemical education. Validity indicators are: (SLM-PC3) is declared to meet the construct validity requirements, if each indicator of thinking skills obtains an assessment with a (Mo) mode of at least 4 from the range of scores 1-5. (SLM-PC3) is declared to fulfill the content validity requirements, if no fatal concept errors are found based on the evaluation of the three validators. The results of the three (SLM-PC3) studies developed have met the requirements of consistency and relevance.**

Keyword: consistency, relevance,ADDIE

I. INTRODUCTION

Through the research scheme of Professor Unesa *PNBP* funding in 2019 wanted to produce Structured Lecture Material for Physics Chemistry 3 (SLM-PC3) which is suitable to be used to practice the three thinking skills of the 21st century demands. Those three skills are argumentation skills (AS), process skills science (PSS), and problem solving skills (PSS). The researcher's argument for paying attention to these three thinking skills is narrated as follows.

The importance of train training in learning science. Researchers agree it is important to train AS to students through the study of Physical Chemistry 3 which is a branch of science [1]. Why does train still have to be trained for students? AS is not an ability that can develop by itself in line with human physical development, but must be trained through the process of providing a stimulus that requires someone to be able to argue [2], [3]. AS's contribution to understanding the concept is as follows. Individuals who are involved in activities which are colored by arguments make them gain a better understanding of concepts [4]. Standford states that argumentation is an important skill in the scientific community and has an important role in the development of new knowledge [5]. Learning science through scientific argumentation has a positive and significant impact on students' understanding of concepts [6].

AS's contribution to other thinking skills is as follows. Liliasari states that AK is the most basic skill in developing critical thinking skills [7]. The same opinion has also been raised by Marttunen, Leena, Litosseliti, & Lund that AK is one of the important competencies needed by students because by arguing it can develop critical thinking skills [8]. It appears that when learning is colored learning experience in the form of argumentative activities, it is actually also practiced critical thinking skills (CTS). Learning science through scientific argumentation has a positive and significant impact on students' ability to argue [6].

AS and CTS eventually also correlate with PSS. Critical thinking is the ability to analyze existing facts and then make several ideas and defend those ideas and then make comparisons. By making several comparisons a person can draw conclusions and make a solution to an existing problem. When someone makes an idea and defend his idea, then this person actually has to build an argument in making conclusions and / or solutions to problems that are solved [6]. It is true that AS, CTS, and PSS are thinking skills that cannot be separated and are very much needed in life. This statement is supported by Trilling & Fadel that the main abilities needed in the 21st century include critical thinking and problem solving [9]. Both of these skills by Trilling & Fadel are expressed as expert thinking. The statement of Trilling & Fadel was reinforced by Mukhopadhyay that the development of PSS in students is one of the current

needs [10]. PSS consists of convergent and divergent thinking to create solutions. PSS involves causal reasoning. PSS can help individuals make the right, careful, systematic, logical, and consider various points of view [11]. Lack of PSS causes individuals to carry out various activities without knowing the purpose and reason for doing so [12].

Besides train and PSS, in learning it is also important to practice SPS. The argument for this statement is as follows. This statement is in line with the recommendations of Ongowo & Indushi that there is a need to make a deliberate effort to develop integrated SPS during the learning process [13]. If SPS is not integrated into the learning process, if SPS is not trained in learning, it is feared that students will memorize facts and develop students' negative attitudes towards science [14]. SPS has a great influence on education because it helps students to develop higher mental processes such as problem solving, critical thinking and making decisions [14]. SPS is an important element in the scientific method [15]. Problem solving in science is the scientific method [16]. Based on these two propositions, SPS is an integral part of PSS. Woolfolk states that if students are trained in SPS by exploring, testing, observing, and organizing information, it can change the thinking process of students and lead to the development of more complex thoughts [17]. According to Ozgelen, SPS is a thinking skill used by scientists to build knowledge in order to solve problems and formulate results [13].

The researcher decided that AS, SPS, and PSS were three of the urgent skills needed to be trained to students through PC3 courses. The results of the analysis of the material in the PC3 course as presented below shows the feasibility of developing SLM-PC3 which trains train, SPS, and PSS [1], [2], [3], [4], [5], [6], [8], [13], and [14].

PC3 lecture material is an empirical or theoretical study of reaction rates as a function of concentration, temperature, and catalyst as well as legal interpretations of reaction rates to the discussion and design of reaction mechanisms [18]. PC3 course learning outcomes are students able to build conceptual conclusions based on empirical facts (inductive thinking) and propose theoretical arguments to explore empirical facts that occur (deductive thinking) in the field of reaction kinetics, so they are able to develop conceptual frameworks based on reaction kinetics for formulate actions or alternative actions in solving chemical problems in life (PC3 Course Syllaby). The main subject matter in Chemistry Physics 3 courses are: (1) Law of Reaction Rate and Reaction Order, (2) Factors Affecting Reaction Rate, (3) Chemical Reaction Theory, and (4) Reaction Mechanism.

Reaction rate law, $r = k[a-x]^m[b-x]^n$can be ascertained after the values of m (first reagent reaction order) and n (second reagent reaction order) are determined based on experimental data [19]. In this study students can be assigned to design experiments. To determine m and n required the ability of students to manipulate one of the reactant concentration variables and control the other concentration variables, and vice versa and be able to see changes in the response variable which in this case is the magnitude of the reaction rate. The ability to design experiments, manipulate variables, control variables, assessing response variables is among the capabilities of the science process (SPS).

One factor that influences the reaction rate is temperature. The quantitative relationship between reaction rate and temperature change is expressed by Arrhenius's law, k = Ae-Ea / RT with k, A, Ea, R, and T respectively the reaction rate constants, Arrhenius constant, activity energy, gas constant, and temperature [20]. This law can be used as a basis for the process of problem solving when when students are asked the problem of how to determine the value of Ea of a chemical reaction.

One theory of chemical reactions is the collision theory. The number of collisions between molecules per unit per volume can be used to predict the value of the magnitude of the reaction rate. The number of collisions can also be used to develop an argument for why the magnitude of the reaction rate increases when the temperature is raised. In designing the reaction mechanism for the overall reaction H_2 (gas) + Br_2 (gas) = 2 HBr (gas) physic chemist writes the breakdown of the Br_2 gas molecule into two radicals • Br as the initiation stage, not the breakdown of H_2 [20]. Students can be assigned to develop arguments for this phenomenon by utilizing data and understanding obtained from previous courses such as Physical Chemistry 1 and 2.

To train AS, SPS, and PSS in PC3 courses more freely if it is packaged in the form of structured assignments. In juridical time allocation of structural tasks more than face to face. Article 17 paragraph (1) Permenristekdikti RI No. 44 of 2015 concerning the National Standards of Higher Education writes that 1 (one) credit in the form of lecture, response, or tutorial learning consists of: (a) face-to-face activities 50 (fifty) minutes per week per semester, (b) structured assignment activities 60 (sixty) minutes per week per semester, and (c) independent activities 60 (sixty) minutes per week per semester [21]. PC3 courses with a weight of 3 Semester Credit System (SCS) get a 3 x 60 minute structural assignment allocation per week per semester. This structured assignment needs to be administered in the form of written lecture materials that are standardized through research mechanisms. Structured Lecture Materials need to be developed for PC3 (SLM-PC3) courses through development research mechanisms.

So that the SLM-PC3 produced can be scientifically justified, it needs to be validated, tested for practicality and effectiveness [22]. If SLM-PC3 based train, SPS, and PSS are not developed, it is feared: (1) the implementation of structured assignments is not optimal, (2) PC3 course achievements are not achieved, and (3) lectures given are not responsive to meeting the needs of students to enter to the 21st century society.

The problem that will be solved through this research is "Are the SLM-PC3 developed feasible to teach students to achieve the minimum ability in the process of science, argumentation, and problem solving?" Three research questions to be answered are: (1) What is the validity of the construction and contents of the SLM-PC3 developed, (2) How is the practicality of SLM-PC3developed, and (3) How is the effectiveness of SLM-PC3 developed?

At present new research holds the first research question. The validity of product development is the assessment carried out by a team of experts on product development that includes content validity (relevance) and construct (consistency). According to Nieveen aspects of validity are met if they meet two things, namely (1) whether the product developed is based on adequate theoretical rational, and (2) whether there is internal consistency [22]. In accordance with Nieveen's opinion, product development can be said to be valid if it meets (1) the compatibility of the supporting theory with the product being developed, and (2) about the components or criteria of the product being developed. The validity of the product development in this study was determined through expert validation.

II. METHOD

The subject of the study was the SLM-PC3 draft consisting of three sets, namely (1) SLM-PC3 Argumentation Skills, (2) SLM-PC3 Science Process Skills, and (3) SLM-PC3 Problem Solving Skills. This development research follows the ADDIE design (Analysis, Design, Develop, Implementation, and Evaluate). The SLM-PC3 draft is the initial result of the develop stage after lattice analysis and design.

The validity of SLM-PC3 is determined in two sub-criteria, namely consistency (construct validity) and relevance (content validity), referring to Nieveen and Plomp recommendations. Consistently fulfilled with the design development meditations that must be met. The SLM-PC3 development design is a blue-print design designed to maintain railroad indicators [23], [24], SPS [25], [26], [27], and PSS [28] in the Physical Chemistry 3. Lattice for SLM-PC3 Argumentation Skills, SLM-PC3 Science Process Skills, and SLM-PC3 Problem Solving Skills are implicitly integrated in the research results table as seen consecutively - according to Table 1, Table 2, and Table 3. Relevance is fulfilled by meditating a principle that product development must not be conceptually wrong. SLM-PC3 written there should not be a wrong concept both from the dimensions of thinking skills and PC3 material content, because this is the highest achievement of the development process. The SLM-PC3 validation instrument was also developed based on the consistency lattice and the relevance lattice.

Data construct validity and content validity based on the assessment given by three experts in the field of chemistry education / learning. In order for the assessments carried out by experts to be consistent and accountable, there needs to be a guide for assessors called rubrics. The rubric in this study certainly contains a set of criteria used to assess the validity of the SLM-PC3 draft. The rubric is as follows: If the score for very high consistency is 5, if the statement is very consistent with what the validator found during observing SLM-PC3, then the score below is successively 4 (high consistency, valid), if the statement matches with what the validator found during observing SLM-PC3; 3 (enough consistency, enough valid), if the validator really is in a state of doubt in giving a score; 2 (lacking consistency, less valid), if the statement is not in accordance with what the validator found during observing the SLM-PC3 draft; and 1 (the consistency is very low, in fact it can be said to be inconsistent, invalid), if the statement is very inconsistent with what the validator found during observing SLM-PC3. For the score given by each assessor on each indicator of the AS, SPS, or PSS, the score scoring mode (Mo) is determined for each criterion given by each validator, then a descriptive analysis is performed.

To determine whether or not there is a consensus among assessors in providing assessment scores, the percentage of agreement is used using Borich's formula [29]. The formula is as follows:

$$Percentageof\ agreement\ (R) = \left[1 - \frac{A-B}{A+B}\right] \times 100\%$$

Note:
R : *percentage of agreement Coeficient* (R)
A : The highest score from validator
B : The lowest score from validator

The criterion of inference of the R value is that the validators are mutually agreed on the assessment given if the R value is ≥ 75% [29]. SLM-PC3 is declared to meet the construct validity requirements, if each indicator of each criterion has a minimum Mo of 4 and no discrepancies between validators are found. SLM-PC3 is declared to meet the requirements of content validity, if no fatal concept errors are found based on the evaluation of the three validators.

III. RESULT

A. Consistency and Relevance of SLM-PC3 Argumentation Skills

The results of the validator's assessment of the SLM-PC3 consistency (construct) Argumentation Skills are presented in Table 1.

Table 1 Consistency Score of SLM-PC3in Argumentation Skill

Statement on Fulfillment of Construction Components and Contents of SLM-PC3 AS as a Supporting Tool for Argumentation Skills Training	Validator Scoring by Validator				*Percentage of Agreement*		
	V1	V 2	V3	M o	V1-2	V1-3	V2-3
Give direction to students to write a statement which is a claim compiled in providing an assessment of a phenomenon [Compiling claims]	4	4	5	4	100	88	88
Give direction to students to write some suitable evidence to strengthen the claims that have been prepared. [Showing proof]	4	5	5	5	88	88	100
Give direction to students to formulate statements to explain the suitability of the evidence presented in strengthening the claims that have been prepared. [Compiling reason]	4	5	5	5	88	88	100
Give direction to students to write a statement and include the reasons proposed to say that a statement is wrong. [Arranging counterarguments]	4	5	5	5	88	88	100

In the format of evaluating the validity of the SLM draft, especially in the relevance assessment section, there was no validator who wrote or stated that the draft SLM-PC3 AS contained a wrong conception both in terms of the thinking skills practiced and from their chemical content. This fact is proof that the draft SLM-PC3 AS developed has met the requirements in terms of content validity (relevance).

By setting a validity standard (construction) with a minimum score mode of 4 and a percentage value of understanding between validators above 75%, an analysis like the following can be given. Of the four criteria representing consistency between SLM-PC3 as a supporting tool for arguing skills training, none of the criteria received an assessment score with a mode below 4. Mode values above 4 namely 5 actually dominated the validator's assessment, 75% of the criteria received a score of 5 (very corresponding). Nor was the percentage of agreement values below 75% found in all criteria used to assess SLM-PC3.

Thus, the SLM-PC3 AS developed by its constructs and contents is very suitable to support lectures enriched with structured tasks. When the construct (consistency) and content (relevance) of a lecture material get a very appropriate assessment from the expert, the lecture can be trusted (valid) to be used to support learning in accordance with the objectives of this teaching material developed. SLM-PC3 AS is stated to have fulfilled the requirements of consistency and relevance as a supporting device for structured lectures.

Table 2Consistency Score ofSLM-PC3SPS

Statement on Fulfillment of Construction Components and Contents of SLM-PC3 SPS as a Supporting Tool for Science Process Skill	Validator Scoring by Validator				*Percentage of Agreement*		
	V 1	V 2	V 3	M o	V1-2	V1-3	V2-3
Load instructions for students to write problem solving correctly.	4	4	5	4	100	88	88
Loading student's directions to write hypotheses using the format "If…, then…"	4	4	5	4	100	88	88
Contains directions for students to write manipulation variables, control variables, and response variables correctly.	5	5	5	5	100	100	100
Contains directions for students to write the definition of manipulation variables and response variables.	4	4	5	4	100	88	88
Load instructions for students to write a proposed experimental plan to answer a given question or question.	5	5	4	5	100	88	88
Load instructions for students to write data organization plans.	5	5	5	5	100	100	100
Contains directions to students to write down the stages of analysis that will be carried out.	5	4	5	5	88	100	88
Contains directions to students to write predictions that might be possible.	5	4	5	5	88	100	88
Contains directives to students to write a presentation design to communicate the results of problem solving that has been done (through a virtual lab).	5	5	5	5	100	100	100

With the availability of the SLM-PC3 AS that meets the requirements of both construct and content validity, we can meet the expectations [1]. Erduran recommended the importance of training in argumentation skills in learning science. SLM-PC3

AS can be used as a stimulus device for the development of argumentation skills in everyone [2], [3]. Students with good argumentation skills have a great opportunity to understand the concept of PC3 [4], [5], [6]. Students who are trained in argumentative thinking will develop into critical human beings [7], [8].

Students' expertise in AS and CTS is expected to have a positive impact on their PSS [6]. Even AS, CTS, and PSS are inseparable thinking skills and are highly needed in life in the 21st century [9], [10]. With SLM-PC3 KA having good theoretical validity, the initial capital is owned to strengthen the flow of chemistry graduates (both education and non-education) to enter the 21st century. In order to make the SLM worthiness more comprehensive, practicality and effectiveness testing in supporting PC3 lectures still need to be done.

B. Consistency and Relevance of SLM-PC3 Science Process Skills

Scores given by the three validators on each criterion for the construction of the SLM-PC3 Science Process Skills are presented in Table 2. In the format of evaluating the validity of the SLM draft, especially in the relevance assessment section, there was no validator who wrote or stated that the SPS SLM-PC3 draft contained a wrong conception both in terms of the thinking skills being trained and in their chemical content. This fact is proof that the SPS SLM-PC3 draft developed has met the requirements in terms of content validity (relevance).

By setting a validity standard (construction) with a minimum score mode of 4 and a percentage value of understanding between validators above 75%, an analysis like the following can be given. Of the nine criteria that represent consistency between SLM-PC3 as a support tool for science process skills training, none of the criteria that get an assessment score with a mode under 4. Mode values above 4 namely 5 actually dominate the validator assessment, 66.67% of the criteria get a score 5 (very appropriate). Nor was the percentage of agreement values below 75% found in all criteria used to assess SLM-PC3. That is, the validators have an understanding in providing an assessment of the validity of developed lecture material.

Table3. SLM-PC3 Consistency Score Problem Solving Skills

Statement of Fulfillment of Construction Components and Contents of SLM-PC3 KPM as Supporting Instrument for Problem Solving Skills Training	**Validator Scoring by Validator**				***Percentage of Agreement***		
	V1	**V2**	**V3**	**Mo**	**V1-2**	**V1-3**	**V2-3**
Load instruction to students to determine variables and / or data related to issues they are facing or facing.	4	4	5	4	100	88	88
Contains directions to students to determine concepts, principles, laws, or theories related to the problem given or faced.	4	4	5	4	100	88	88
Load instructions for students to re-examine the reciprocal (causal) variables-variables related to a given problem or problem.	4	4	5	4	100	88	88
Contains directions for students to write thinking frameworks based on concepts, principles, laws, or related theories to guide the problem solving process.	4	5	5	5	88	88	100
Contains directions for students to write the results of the development of problem solving plans based on the framework of thinking that has been made.	4	5	5	5	88	88	100
Contains directions for students to write arguments for the choice of problem solving strategies.	5	4	5	5	88	100	88
Contains directions for students to write down targets for problem solving.	5	5	5	5	100	100	100
Load student instructions to write the sequence of work steps according to the problem-solving plan you have created.	5	5	5	5	100	100	100
Load instructions for students to write proof of problem solving implementation.	5	5	5	5	100	100	100
Contains directions for students to write the results of evaluations about the implementation of problem solving in terms of phasing / mechanism of work planned.	5	5	5	5	100	100	100
Contains direction for students to write the evaluation results about the achievement of the problem solving targets.	4	5	5	5	88	88	100
Contains directions for students to write draft documents to communicate the results of problem solving.	4	5	4	4	88	100	88

Thus, the SLM-PC3 SPS developed by the construct and its content is very suitable to support lectures enriched with structured tasks. When the construct (consistency) and content (relevance) of a

lecture material get a very appropriate assessment from the expert, the lecture can be trusted (valid) to be used to support learning in accordance with the objectives of this teaching material developed. SLM-PC3 SPS is declared to have fulfilled the requirements of consistency and relevance as a supportive tool for structured lectures.

The availability of valid SLM-PC3 SPS is a basic capital for fulfilling expectations for SPS training in lectures [13]. Concerns about students memorizing facts and developing students' negative attitudes towards science as revealed by Jack will be reduced when lectures are supported by this SLM-PC3 SPS device [14]. Like argumentation skills, a good KPS will boost PSS, CTS, and decision making [14]. The availability of valid SLM-PC3 SPS can be utilized to support scientific method based learning [15], so that graduates of Chemistry Education S1 are no longer awkward in carrying out curriculum implementation in schools. Problem solving in science is the scientific method. SPS is an integral part of PSS [16], [13], so in learning chemistry that facilitates SPS with a valid device is expected to have a positive impact on the development of student PSS. In order to make SPS SLM-PC3 worth more comprehensive, it still needs to do a practical test and test its effectiveness in supporting PC3 lectures.

C. Consistency and Relevance of SLM-PC3 Problem Solving Skills

Scores given by the three validators on each criterion for SLM-PC3 consistency Problem Solving Skills are presented in Table 3.

In the format of evaluating the validity of the SLM draft, especially in the relevance assessment section, there was no validator who wrote or stated that the KPM SLM-PC3 draft contained a wrong conception both in terms of the thinking skills being trained and in their chemical content. This fact is proof that the PSS SLM-PC3 draft developed has met the requirements in terms of content validity (relevance).

By setting a validity standard (construction) with a minimum score mode of 4 and a percentage value of understanding between validators above 75%, an analysis like the following can be given. Of the 12 criteria that represent consistency between SLM-PC3 as a supporting device for problem solving exercises, none of the criteria that score scores with mode below 4. Mode values above 4 namely 5 actually dominate the validator assessment, 66.67% criteria get a score of 5 (very appropriate). Nor was the percentage of agreement values below 75% found in all criteria used to assess SLM-PC3. That is, the validators have an understanding in providing an assessment of the validity of developed lecture material.

Thus, PSS SLM-PC3 developed construct and its contents are very suitable to support lectures enriched with structured tasks. When the construct (consistency) and content (relevance) of a lecture material get a very appropriate assessment from the expert, the lecture can be trusted (valid) to be used to support learning in accordance with the objectives of this teaching material developed. SLM-PC3 KPM is stated to have fulfilled the requirements of consistency and relevance as a supportive tool for structured lectures.

The three SLM-PC3s developed have been declared to meet the requirements of consistency and relevance. In accordance with Nieveen's (2007) statement, these three learning tools have adequate theoretical rational foundations and have internal consistency. It has a very high theoretical rationale and internal consistency (obtaining the majority of the highest scoring scores, 5) for the three SLM-PC3 developed because: (1) the formulation of content and activities in these modules has been based on strong theoretical arguments especially regarding skills thinking and understanding about PC3 material, (2) theoretical foundation on phasing in thinking skills training, and (3) chemical materials (chemical facts, concepts, etc.) that are content in SLM-PC3 in accordance with chemical scientific principles or not contain misconceptions.

With three SLM-PC3s that have fulfilled theoretical validity to train AS, SPS, and PSS, the recommendations made by Erduran [1], Muslim [2], Sadler [3], Cetin [4], Standford [5], Chen & She [6], Litosseliti & Lund [8], Ongowo & Indushi [13], and Jack [14] will be fulfilled by researchers as supporting PC3 subjects. Three thinking skills of AS, SPS, and PSS are three Urgent skills will be able to be trained to students through PC3 courses, after the practicality and effectiveness data obtained are developed.

IV. Conclusions

Three SLM-PC3 have been produced, namely SLM-PC3 Argumentation Skills, SLM-PC3 Science Process Skills, and SLM-PC3 Problem Solving Skills that meet the requirements of construct and content validity. These three SLM-PC3 are stated to have fulfilled the requirements of consistency and relevance. The next step to be carried out is to carry out an implementation to evaluate its practicality and effectiveness according to the ADDIE development plan.

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