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Development of Student Worksheet for Improving the Self-efficacy and Ability to Argue of Chemistry Teacher Candidates

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***Abstract*—The purpose of this study is to explain the validity of student worksheets based on argumentation and self-efficacy learning that has been developed. The development of the student worksheets refers to the design of the Wademan model development research model. The student worksheet applied phases of the Graphic Organizer-based Argumentation Learning (GOAL) model to improve the self-efficacy and ability to argue of chemistry teacher candidates. This worksheet encouraged students to identify chemical problems, formulate problems, submit hypotheses, formulate learning goals, conduct investigative activities, make arguments, present chemical arguments, and make conclusions. The components of the validated student worksheet include format, material, language, and assessment of student worksheets in supporting innovation and improving the quality of teaching and learning activities. The data of this study were collected using a review and validation sheet. Sources of the data were chemistry education lecturer. The data were analyzed descriptively. The results showed that the validity for each aspect of the assessment was in the range of good validity and very good validity criteria. Therefore, the developed student worksheets are appropriate to be used to facilitate students in chemistry the learning process.**

Keywords—student worksheets, model Graphic Organizer-based Argumentation Learning (GOAL), argumentation skills, self-efficacy

I. INTRODUCTION

Scientific arguments are understood in written and verbal terms as products and processes [1]. Understanding the relationship between verbal and written scientific arguments is believed to help success in learning organic chemistry [2]. Learning that focuses on argumentation can improve students' conceptual understanding [3-6] and the quality of argumentation [7,8]. The low level of argumentation skills influences the low understanding of chemical concepts [4,6,9]. The understanding of student chemistry concepts is better in the experimental class based on argumentation than the control class [9]. Arguments-based chemistry learning has been shown to increase students' understanding of the concept of reaction rate [6], and can help students understand topics that are difficult to learn [4]. Research-based on the argumentation approach also shows that students can develop a better understanding of chemistry in general and specifically the concept of acid-base [10]. For that reasoning skills need to be developed in chemistry learning, because it can improve critical thinking to test students' understanding of concepts.

Argumentation skills are one of the competencies needed today because by arguing, critical thinking skills can develop [11]. Osborne, Erduran, & Simon [12] reveal that the ability to argue is needed to address problems related to scientific issues that occur in every aspect of people's lives today, which requires every individual and society to have the ability to think, make decisions, consider ethics and assess a claim that appears both through mass media and other media based on valid and reliable evidence. In addition, arguing can also improve student performance and science learning outcomes [13-15]. Argumentation must be taught and learned in science class as part of scientific inquiry and literacy [1,16,17]. Arguments can be described as discourses in which claims of knowledge are individually and collaboratively constructed and evaluated with empirical or theoretical evidence [1]. On the other hand, arguing is part of the behavior of making decisions and defending them, influencing others according to data accompanied by rationalization [18]. This decision can be in the form of an answer to a problem or belief in the findings [19]. Arguing also means building socio-cultural activities through presentation, interpretation, criticism, and revision of an argument [20].

Learning that involves argumentation is a challenge for students, for example, students are often asked how to give an explanation of "why and how things can happen" in activities designed so students are involved in arguing. For this reason, students must struggle in this process and be confident in their beliefs [21]. Confidence in all abilities includes self-confidence, adaptability, cognitive capacity, intelligence, and capacity to act in stressful situations. In other words, self-efficacy is needed in the implementation of argumentation skills. Self-efficacy is important because it can affect cognition, motivation, affective processes and ultimately people's behavior [22-24].

The learning model that facilitates and encourages students to develop argumentation and self-efficacy skills with the use of a graphic organizer in the learning process is the Graphic Organizer-Based Argumentation Learning (GOAL) model which can integrate argumentation and self-efficacy skills, which are developed in reference to cognitive learning theory, social cognitive learning theory, information processing theory, and constructivist learning theory [25]. The GOAL model is a quality learning model because it is valid in content and construct, and reliable for improving student argumentation and self-efficacy skills [26]. The GOAL model consists of six phases. These are: 1) explaining the objectives and identifying the chemical problems; 2) modeling graphic organizer-based chemical arguments; 3) investigating chemical problems; 4) presenting chemical arguments; 5) transforming chemical arguments through writing; and 6) examining the understanding of argument-based chemistry and providing feedback. The implementation of the GOAL model requires learning tools as a form of operationalization of the model, including the Student Worksheets. Student worksheets are an integral part of the instructional design prepared to facilitate the learning process [27]. The advantages of worksheets are facilitating lecturers in implementing learning, while for students can help them to learn independently and understand and complete tasks [28]. For this reason, it is necessary to develop student worksheets that can support and facilitate students in the process of learning organic chemistry that integrates student argumentation and self-efficacy skills.

II. RESEARCH METHOD

This development research aims to develop student worksheets as a product that is valid, practical, and effective [29,30] in improving students' argumentation and self-efficacy skills. The validity of student worksheets is the quality of student worksheets that are assessed by validators. Practicality is a student worksheet that is developed must be realistic and can be applied by lecturers and students. Effectiveness is the application of student worksheets that produce the desired impact and the presence of positive student responses to student worksheets. The development of the student worksheets refers to the design of the Wademan model development research model. Steps to develop the Wademan model [30] include 1) identification of problems, 2) tentative identification of product principles and designs, 3) tentative theories and products, 4) making prototypes and assessing product quality, and 5) improving product quality.

The student worksheets that have been developed are then assessed by experts using an instrument in the form of a validation sheet. This validation sheet is filled by experts who examine and assess the quality of each student worksheet component developed by the researcher. The scale of the score used in the student worksheets validation sheet is 1 to 4, which is score 1 for the criteria that are not good, score 2 for the criteria is good enough, score 3 for the criteria is good, and score 4 for the criteria is very good. The student worksheets are declared feasible for use if the minimum level of validity reaches a valid category with a minimum score of 2.50 [31]. The reliability test of the student worksheets validation sheet is based on the consistency of the student worksheets validation sheet when it is used to validate the student worksheets by the validator. Reliability analysis of the learning model validation sheet uses a percentage of observer agreement [32]. Furthermore, the student worksheets are used in the learning process of organic chemistry I in the class. Student responses to the use of student worksheets are determined based on the response questionnaire filled in by the students after the completion of the learning process. Student response data obtained were analyzed descriptively qualitatively.

III. RESULT AND DISCUSSION

The student worksheets are a guide for students in conducting learning activities. Four student worksheets were developed, "Structure and Physical Properties of Alkyl Halides", "Nucleophilic Substitution Reaction (S_N2)", "Nucleophilic Substitution Reaction (S_N1)", and "Elimination Reaction". The components of a validated student worksheets include: 1) Format, 2) Material, 3) Language (the readability of the language or language used in accordance with the age of students, using communicative and effective languages, terms and symbols used appropriately and can be understood and used steadily, use good and correct Indonesian language), 4) Presentation, and 5) Student worksheets assessment in supporting innovation and improving the quality of teaching and learning activities. A summary of the validity scores for each student worksheet component is shown in Table I.

TABLE I. RESULTS OF STUDENT'S WORKSHEET QUALITY ASSESSMENT

No.	Aspect of Assessment	Validation Score			Criteria	Reliability Coefficient (%)	Reliability
		V1	V2	V3			
1	Format	4	4	4	Very Good	100	Reliable
2	Material	4	3	3	Good	83	Reliable
3	Language	4	4	4	Very Good	100	Reliable
4	Presentation	4	3	4	Very Good	92	Reliable
5	Assessment of student worksheets in supporting innovation and improving the quality of teaching and learning activities	4	3	4	Very Good	92	Reliable

The results of expert evaluations of the validation of student worksheets that are developed are very valid criteria. The level of consistency between experts on the overall composition of the student worksheet's validation is very high. The validity criteria of the student worksheets validation components based on Table 1, all meet very valid criteria. For example, the material aspects on this worksheet are considered valid, because they are considered to be able to encourage students to understand and master the concepts of alkyl halide compounds. The material on the worksheet is arranged according to the technical structure. By completing the first worksheet students are expected to be able to relate the relationship of structure to the physical properties of alkyl halides. On the second and third worksheets, students can master the S_N2 and S_N1 reaction mechanisms. While the material on the fourth worksheet focuses on students' mastery of the concept of eliminating the alkyl halide reaction. The assessment aspects of student worksheets in supporting innovation and improving the quality of teaching and learning activities are also categorized as very valid because the worksheets provide convenience in developing argumentative and self-efficacy skills. On worksheets, argumentation skills are trained through the activities of making arguments, presenting chemical arguments, and writing simple articles. Activities on the worksheet are also designed to foster self-efficacy through activities formulating objectives, conducting investigative activities, presenting chemical arguments, and writing simple articles. Thus the student worksheets developed can be used as a learning resource in chemistry learning to improve students' argumentation and self-efficacy skills. As stated by Supeno [27], Rasmawan [33], and Widodo et al.[34]; that student worksheets that have been declared valid by the expert contain the meaning of the student worksheets that have met the criteria standards that have been determined and are suitable for use in the learning process. The activities contained in the student worksheets have been designed so that students carry out their argumentation skills and foster student self-efficacy, so that students can carry out argumentation skills in accordance with the directions contained in the student worksheets, understand chemical material and foster student self-efficacy. This is in accordance with the opinion of Supeno, et al. [27] who stated that learning is needed by student worksheets so that activities carried out by students can be directed because student worksheets can be developed according to the material framework and skills that will be taught to students. Some literature also states that student worksheets can direct student learning activities [35], help students understand the material, solve problems, and help students discuss [36].

The student worksheets are developed based on learning outcomes, final abilities, and indicators on syllabus and alkyl halides' lesson plan. Such development of student worksheets is in accordance with the opinion of Widodo et al. [34] which states that the process of developing student worksheets must be carried out by considering the lesson plan and syllabus that has been developed. Student worksheets that are developed accommodate the phases in the syntax of the GOAL model. This can be seen from the activities carried out, namely identifying chemical problems, formulating problems, submitting hypotheses, formulating learning objectives, conducting investigative activities, making arguments, presenting chemical arguments, and making conclusions. The Graphic organizer of the chemistry argument made by students in the activity of making arguments is characteristic of student worksheets that can practice argumentation skills. As stated by Bulgren and Ellis [37] that Graphic organizers provide space for each step of the argumentation process. In the phase of transforming chemical arguments through writing, students are given written arguments by student worksheets. The student worksheets in written arguments are specifically used to develop students' written argument skills, in accordance with the opinion of Kingir [38] which states that writing can improve students' critical thinking skills and reasoning about the meaning of data.

This student worksheet discusses organic chemistry I which includes the material on the structure and physical properties of alkyl halides, nucleophilic alkyl halide substitution reactions, SN_1 and SN_2 reaction mechanisms, and elimination reactions of alkyl halides, for that the worksheet is also equipped with references. Students' understanding of the material will be stronger because the student worksheets contain references that can be used by students to read more about the material discussed [28]. The use of argumentation-based student worksheets can help improve student argumentation skills [39]. This is done to provide opportunities for students to learn how to design and conduct informative investigations, analyze data, and understand how the scientific process works.

The simplicity of sentence structure, the suitability of sentences with the level of thinking of students, the language used according to the age of the students, clarity of instructions and direction, and the terms, formulas, and symbols used consistently, make students comfortable and easy to use the student worksheets. This is reinforced by student response data indicating that students feel interested and easy when using student worksheets, students also state that student worksheets are new.

IV. CONCLUSIONS

The student worksheets developed in this study are included in very valid criteria so that it is appropriate to be used to support and facilitate students in the process of learning organic chemistry that integrates student argumentation and self-efficacy skills.

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