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THE DEVELOPMENT OF SCAFFOLDING IN INQUIRY-BASED LEARNING TO IMPROVE STUDENTS' SCIENCE PROCESS SKILLS IN THE CONCEPT OF ACID AND BASE SOLUTION

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ABSTRACT

The technique of providing learning support in a structured manner to encourage students to learn independently is called scaffolding. This consists of four types questioning, prompting, cueing, and explaining. This study aims to describe the procedure for developing scaffolding in inquiry-based learning that is beneficial to improve students' science process skills in the concept of acid and base solution. The heuristic method in the type of F2-O3-S1+S5+S6-A3 was used in this study to develop the design of the scaffolding. The data were collected using an interview and analyzed using a Delphi technique. Based on the expert validation, it was seen that the scaffolding technique designed was suitable for use. The results of the student trial also showed that the scaffolding technique was effective to be used to improve students' science process skills. It can be concluded that the scaffolding technique on inquiry-based learning was able to improve students' science process skills in the concept of acid and base solution.

***Keywords:** Scaffolding, Inquiry Model, Science Process Skills, Acid, and Base Solution*

INTRODUCTION

Chemistry learning requires more understanding than memorization so that the learning approach or strategy contributes to improving students' ability to understand a concept [1]. Understanding the concept is a way of understanding something that has been patterned in his mind, which is accessed by verbal or written symbols. The still weak ability of students in understanding chemical concepts can be caused by the lack of proper teaching staff to provide learning support to students in understanding these chemical concepts [2].

The technique of providing structured learning support that is carried out at an early stage to encourage students to learn independently is called the scaffolding learning strategy [3]. In learning, students with low abilities take longer to understand concepts than students with medium and high skills without any intervention or assistance [4]. The use of scaffolding in learning can minimize what educators do by emphasizing the interaction of students in the learning process, facilitating learning, providing assistance in the form of guidance, providing examples, keywords that can lure students towards independent learning. Not only that, but scaffolding also directs students who experience high ZPD (Zone of Proximal Development) to help students who have low ZPD so that students can focus on achieving learning goals [3]. Vygotsky stated that ZPD is an area between levels of real development, which is defined as the ability to solve problems under the guidance of adults or peers who are more capable [3]. The use of scaffolding will provide assistance to educators to assess the obstacles faced by students during learning and use it as an aid to identify solutions to these obstacles [5].

The application of scaffolding in chemistry learning requires the support of an appropriate learning model to maximize the achievement of student development abilities. The purpose of inquiry learning is to prepare students to be able to solve problems faced in everyday life using scientific concepts [6]. The application of inquiry in the learning process has constraints, including a long time with a large number of students in one class so that the application of this model is not significant [7]. The limited understanding of educators to the inquiry will also cause errors in its implementation, such as the difficulty in distinguishing the role of educators and deciding how much help should be given to students in the learning process [7]. Constraints in carrying out inquiry can be minimized by using a scaffolding learning strategy because educators have a clear role in providing gradual assistance to students during the learning process. This makes the time needed during the learning process relatively shorter. The application of scaffolding in the learning model provides significant results in helping students solve problems during learning [8].

The purpose of the inquiry is the same as the goal of science process skills that students must have in chemistry lessons carried out by the practicum method. Increasing science process skills will affect the activities of students to explore chemistry subject matter [9]. However, in the learning process, there are still many students who tend to be passive, only accepting the material being taught, without wanting to study more deeply and continuously (minimal Student Science Process Skills), the lack of student initiative to ask the teacher, if asked for examples in everyday life, then students will give the answer by what is provided by the teacher, and students are not used to being faced with problem-based learning [10]. Chemistry learning materials that are often carried out using the practicum method are the concept of acid and base solution. This concept is studied in XI grade.

The implementation of inquiry in learning, according to K13, does not give significant results [7]. This is evident from the results of the Program for International Student Assessment (PISA) in 2015 study on the science aspect, Indonesia was ranked 62 out of 71 countries involved with a score of 403 [11]. In PISA, there are three aspects of science, namely explaining scientific phenomena, evaluating and designing scientific research, interpreting data and scientific evidence, which are components of scientific process skills including observing, predicting/ predicting, applying concepts, and communicating [12]. From these results, it can be concluded that the science process skills of students in Indonesia are still far below the average level of students from countries participating in

PISA, so they must be improved [11]. With the description above, it can be concluded that to accommodate the weak science process skills and the implementation of inquiry in learning, educators need to change their teaching practices.

METHODS

The development procedure in this study was modified based on the research procedure for the development of the learning design model, namely type F2-O3-S1 + S5 + S6-A3 [13]. The steps in the scaffolding development procedure in inquiry consist of 7 steps, namely (1) determining data sources, (2) collecting data, (3) analyzing data, (4) generating ideas, (5) describing the model, (6) performing validation concepts, (7) Perform practitioner validation.

Validation is carried out in two stages, validation of concepts and validation of practitioners. Concept validation was carried out to 2 experts, namely scaffolding design experts and learning design experts who tested the product's feasibility conceptually. Practitioner validation was carried out on three educators who tested the feasibility of the product procedurally.

The data collection instrument used in this study was an interview guide (interview protocol) using the data collection technique, namely the Delphi technique. The interview instrument was made based on the rules of the National Education Standards Agency, the learning design model [14], and the criteria for validating the product [15].

The research was carried out on a small scale in Senior High School 3 Jambi City by testing the feasibility of the resulting product in the form of scaffolding procedures and student scaffolding worksheets. The number of participants involved was 36 students.

The data obtained are qualitative because they come from the opinions of experts and practitioners. Furthermore, the data were analyzed by following the pattern in the spiral model, which has been modified for design and development research [15].

RESULTS AND DISCUSSION

The development of scaffolding in the inquiry model has the hope of conditioning the development of a procedural learning design model using a hybrid approach, with the ultimate goal of being able to determine data sources from theory-driven, followed by practice-driven through the integration of expert opinion. And practitioners with heuristic design patterns.

1. Determine the data source

The first step is to determine the data source to support scaffolding development in an inquiry. The data needed include the curriculum related to basic competencies as the main guide in developing products based on learning materials [16]. Furthermore, the constructivism learning paradigm is the basis for designing learning so that students are able to build and interpret knowledge from their own experiences Zone of Proximal Development (ZPD) is the basis for developping scaffolding that is in accordance with the zone of student learning development [15]. Scaffolding can be a benchmark in determining what treatment should be done to students during the learning process [18]. The inquiry learning model is used to design learning activities through six syntaxes [19], then science process skills are used as a basis for developing learning in order to obtain an increase in the students' abilities, and the characteristics of acid and alkaline solution material along with practicum procedures.

2. Collecting data

The data collection stage was carried out by reviewing the literature from books, journals, articles, and other sources that were relevant and related to the development of scaffolding procedures and scaffolding student worksheets on inquiry.

3. Analyzing data

The stage of analyzing data is done by connecting information from data that has been obtained. Then examine the data so that each approach can be linked according to information needed in developing scaffold-ding in the inquiry model. The results of this data analysis obtained a relationship between the syntax of the inquiry model, scaffolding, and science process skills. The six inquiry syntaxes are given each of four examples of scaffolding that educators can use. In each syntax, the relationship between students' science process skills that can be raised can be analyzed. The results of the relationship between the investigative model syntax, scaffolding, and science process skills can be seen in Figure 1.

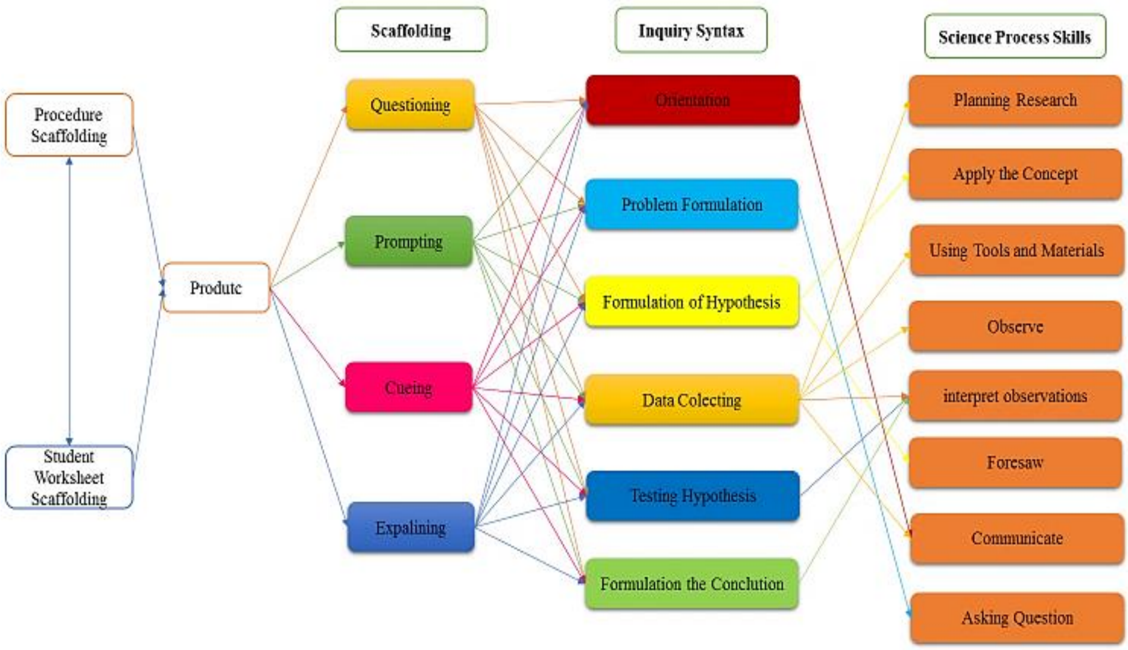

Figure 1. Relationship between the syntax of the inquiry model, scaffolding and science process skills

4. Come up with ideas

The stage of generating ideas is carried out by looking for integration patterns from the data obtained and then transforming them into the stage of giving scaffolding on inquiry in the form of products that can be used in the learning process. The scaffolding product in inquiry developed is in the form of scaffolding procedures and scaffolding works-sheets for educators and students as learning media.

The scaffolding procedure on inquiry is made based on the different objectives of each syntax that must be achieved by students. In line with the objectives of each syntax, each syntax has an ideal type of scaffolding. However, this ideal type of scaffolding in its implementation in the learning process is not absolute but flexible, and educators can freely adjust it to the existing learning environment in the field. The scaffolding procedure on inquiry is also described in each syntax, the decisions that the educator must take before finally being able to enter the next syntax. Educator's decision making is in the form of 'yes' and 'no' choices.

Worksheets for educators and students are in the form of practical implementation procedures to identify the acid and alkaline solutions. However, student educator works-heets and students have significant differences, namely in the educator worksheets in each inquiry syntax is equipped with a list of types of scaffolding that can be used. Meanwhile, the worksheet in each inquiry syntax contains activities that must be done during the learning process. The material in both teacher worksheets and student worksheets is made the same. This aims to make it easier for educators to provide explanations related to the subject matter. In the final stage, the student worksheet is equipped with an evaluation using questions to test students' understanding after the learning process is carried out using scaffolding on inquiry.

5. Explain the model

The stages of describing this model are making designs and scaffolding procedures and worksheets with a pattern that has been designed. The results obtained at this stage are the initial products of scaffolding development on inquiry. Scaffolding is arranged in the form of an algorithm flowchart in which there are activities and educators' decisions on each inquiry syntax. Each syntax in the scaffolding procedure is distinguished by a certain color to make it easier for educators to understand the procedure.

This student worksheet is designed using the Canva application. Part of the student worksheet consists of a cover, a brief explanation of scaffolding in inquiry, a table of contents, competencies, a brief explanation of inquiry syntax, concept maps, the basic theory of acid and base solutions, syntax inquiry activities using the practical method of identifying acid and base solutions and evaluation using questions.

6. Concept Validation

Concept validation aims to assess the feasibility of a product conceptually and is carried out on two experts, namely scaffolding design experts and learning design experts. I After scaffolding validation, the expert provides suggestions regarding product improvements which in turn can improve the quality to be produced . the validation of the scaffolding design, the expert assesses that there are fundamental deficiencies of the scaffolding design that was developed so that the overall improvement is carried out. According to experts in scaffolding design, ideal scaffolding should be added or, more importantly, used in each inquiry syntax. This is because, during the learning process, the implementation of the inquiry syntax will be different depending on the goals and responsibilities given to students from the beginning to the end of the learning process. The results obtained during this validation stage are based on the inquiry syntax can be seen in Table 1.

Table 1. Data on the results of the Scaffolding design validation for inquiry syntax

No	Syntax Inquiry	Scaffolding Type
1	Orientation	Explaining
2	Problem formulation	Explaining/cueing
3	Formulation of hypothesis	Cueing /prompting
4	Data collection	Explaining/ cueing/ prompting/ questioning
5	Testing hypothesis	Prompting/ questioning
6	Formulation of the conclusion	questioning

Based on Table 1, it can be seen that at the beginning of the study the level of scaffolding that was given was quite a lot. We can find that the core activity of the scaffolding level used begins to decrease, namely cueing and prompting as the learning process takes place towards the end of the scaffolding level which is increasingly rarely used. The reduction or fading of this level of scaffolding is continuous with the increased responsibility given to students during the learning process [20].

The responsibility of students in the early stages of learning is less so that the scaffolding used by educators in helping students must be more. Conversely, at the end of the learning process, the responsibility of students towards the learning process is greater so that the scaffolding used will be less. By giving the level of student responsibility and the type of scaffolding used by educators from the beginning to the end of the lesson it has several impacts on students. There is a fading or reduction of scaffolding and an increase in responsibility by students gradually.

In the validation of the learning design, experts assess that there are deficiencies in the evaluation section provided. The form of evaluation should be given in the form of questions to determine the level of understanding and the successful achievement of improving students' science process skills. The addition of questions to this evaluation must be adjusted to the domain of learning objectives, such as for the cognitive domain, evaluation in the form of objective tests and tests with structured responses can be used [14].

7. Validate Practitioners

Practical validation aims to determine the effectiveness of using scaffolding procedures and scaffolding student worksheets in the actual learning process. This practitioner validation also aims to ensure that there are no more significant deficiencies in the procedures and student worksheets that have been validated by experts.

In addition to obtaining educators' responses to scaffolding procedures and student scaffolding worksheets, at this stage, small group trials were also carried out. The purpose of this trial is to determine the implementation of the ideal types of scaffolding in each inquiry syntax.

The results obtained from practitioner validation were carried out by the interview stage, from the aspect of the product material produced was good and was able to provide understanding to students of the material because it was equipped with pictures and chemical formulas. Furthermore, from the aspect of the design of the learning procedure and the student worksheets, scaffolding is good and can be implemented in the learning process. Even so, educators suggest that in implementing scaffolding in inquiry learning for this type of explaining, students should be conditioned to play a role in finding. This is in accordance with the essence of inquiry, namely finding, so it should be in the implementation of explaining, even though there has been an explanation that must be provided by educators. However, it is still directed by students to find their concepts from the material they are learning. Furthermore, students must be sure to follow each syntax because if students are not able to meet the demands of the syntax, it will be difficult to advance to the next syntax so that the cognitive load will be greater. Then in the implementation of procedures and student worksheets, scaffolding must pay attention to the time allocated to each syntax because with the many activities that must be done, students worry that learning will not be completed.

At this validation stage, the product feasibility test is carried out. The result that we can see is a decrease in the level of scaffolding assistance provided from the beginning to the end of the lesson. In line with these findings, the percentage of four types of scaffolding based on the estimation and interpretation of the test results for each inquiry syntax can be illustrated as in Figure 2.

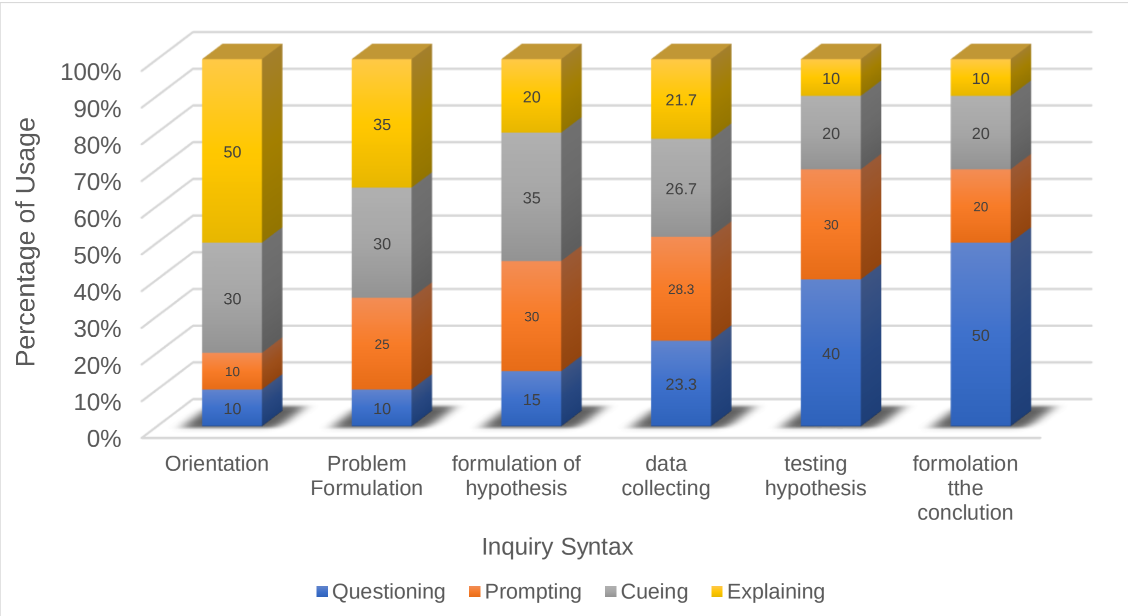

Figure 2. Percentage of Scaffolding Type Use in Inquiry Syntax

The findings obtained from the results of trials about the type of fading scaffolding used from the beginning to the end of the learning process can be illustrated in the form of students' ZPD schemes at the initial stages of learning that require guidance in the form of more assistance for students [21]. Furthermore, help is reduced to produce more help in the form of questions to students [21]. Therefore, the use of scaffolding in the investigation model of the research results can be illustrated in Figure 3.

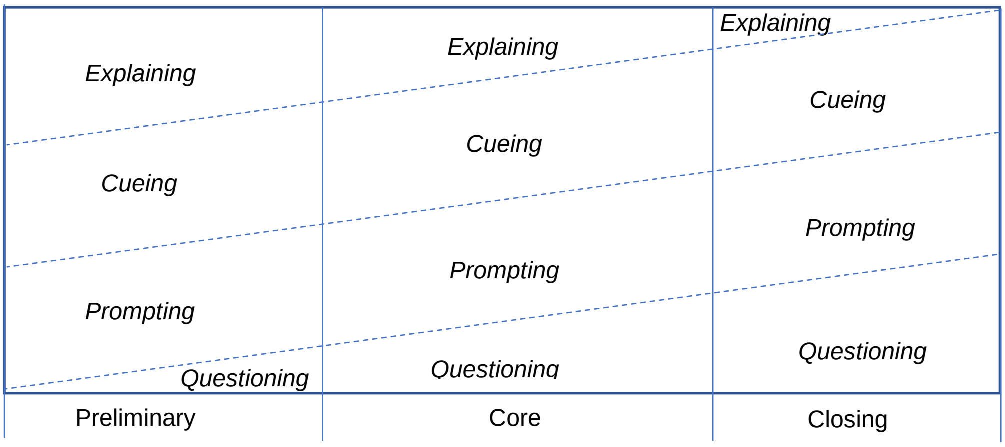

Figure 3. The use of scaffolding during the inquiry learning process

Based on Figure 3, it can be seen that there is a fading scaffolding that explains from the initial activity to the closing activity. on the contrary, in this case the scaffolding still has doubts in increasing the provision of assistance. the provision of assistance in question is from the beginning to the end of the lesson. This is due to the activities of early educators who will provide more assistance while the student responsibility is still small. But as the learning process continues, the assistance provided by educators will gradually be reduced until the responsibilities of the student participants increase. This causes the closing activities of assistance provided by educators will be much smaller while student responsibilities will be greater. Overall the number of four types of scaffolding in the investigation model can be seen in Figure 4.

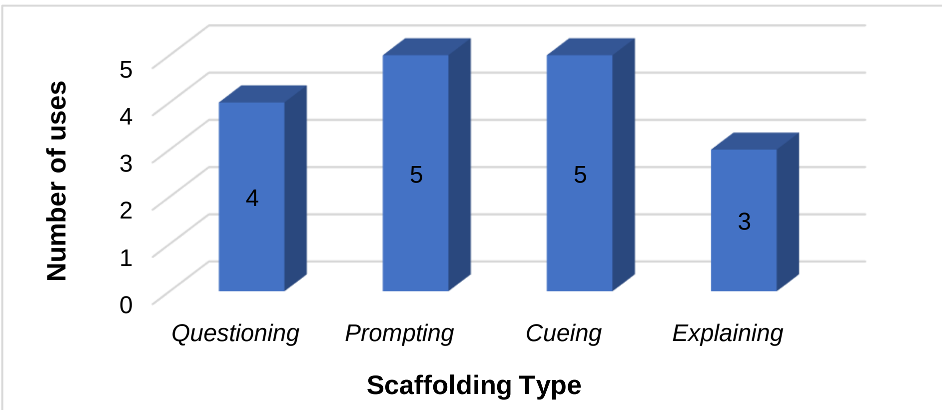

Figure 4. The use of scaffolding types in inquiry

Based on Figure 4, it can be seen that the most common use of scaffolding is to encourage and give signals. This can be caused because, in each syntax of the inquiry model, students need guidance but are also required to be able to determine scaffolding questions and explanations that are not used. can provide more information that for this level of assistance and explanation level will only appear at the end of the lesson. At the same time, the core activities of the inquiry model, students find that what will emerge is a type of scaffolding prompt and cueing. After a series of development and improvement processes at each stage, the final flow and scaffolding of the student worksheet are aimed at educators and students.

After a series of development and improvement processes are carried out at each stage, the final results are obtained in the form of scaffolding procedures and scaffolding student worksheets intended for educators and students. During the development of scaffolding products on inquiry, several obstacles were encountered. The main obstacle occurs in the application of the product, namely time constraints, because the application of inquiry requires a long time. This occurs based on the test results on the last syntax, namely formulating conclusions, the time provided for 90 minutes is not sufficient to carry out this syntax properly. Therefore there is a need for the ability of educators to be able to streamline the time for implementing learning in accordance with the learning process plan that has been made.

The weakness of the resulting final product in the form of scaffolding procedures on inquiry is not absolute and standard in its application during the learning process. This is because if the scaffolding procedure is applied to different materials, models, students, and learning environments, the scaffolding given will be different. This also causes educators to be expected to be able to quickly select the right scaffolding by conducting dynamic assessments to determine the type of scaffolding given. This does not apply equally to the use of student worksheets, because these worksheets are developed based on a syntactic sequence of inquiry adapted to scientific processing skills and acid-base solution material. so that their use in inquiry learning cannot be changed.

The use of product scaffolding proce-dures and scaffolding student work-sheets in learning when it has been carried out effectively will increase the science process skills of students. it is possible that this will not be implemented at every request in the syntax model. If this happens, the educator, after conducting dynamic assess-ments, can immediately provide more explaining type scaffolding assistance. Achievement of students' science process skills cannot be ascertained because product trials are carried out only on a small scale test, and in practice, students work on scaffolding student worksheet in groups. This makes the resulting product unable to see each student's constraints and cannot be efficient in applying scaffolding to each student individually.

CONCLUSION

This research has resulted in a product in the form of procedures and student scaffolding worksheets on inquiry. Procedures and student scaffolding worksheets on inquiry were developed using a modified procedural model as needed. The resulting products are intended for educators and students. The results of expert and practitioner validation obtained by interview show that the conceptual scaffolding design and learning are declared fit for use and the procedural validation results of practitioners also state that the product is suitable for use related to material aspects and learning design. Furthermore, from the results of small-scale trials of the product, it can be seen that the product is effectively used in the learning process and can improve students' science process skills in the concept of acid and base solution. However, an obstacle arises for the final product, which cannot be absolute and standardized in the learning process.

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