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Implementation of Scaffolding Assisted Project-Based Learning Models in Buffer Solution Materials

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ABSTRACT

This study was conducted to solve of applying the learning model to skills and scientific process results in Buffer Solution learning materials in senior high school (SMA). In the early stages, the researchers designed scaffolding by linking the PjBL Flipped Classroom model, KPS, and buffer solution material. Then, these two products were validated by a team of experts involving scaffolding design validation, flow validation, learning design validation, and material validation to see the suitability of the scaffolding assistance at each stage of the PjBL Flipped Classroom model and the feasibility of the products developed and required to adopt the products produced to the principles set found in learning design. After completing the validation stage, the practitioner validation stage is continued to see the practicality of using the product being developed. Then a small group test is carried out to see the application of the product being developed. The results showed that learning chemistry using the Scaffolding Flow in the PJBL Flipped Classroom model could increase students' chemistry learning activities and outcomes on the concept of buffer solutions.

KEYWORDS: Project-Based Learning Models, Scaffolding, senior high school (SMA), buffer solutions

I. INTRODUCTION

Based on the results of the 2015 Program for International Student Assessment (PISA) research, Indonesia's scientific grades are still in a low ranking. Of the 70 PISA member countries, Indonesia's education is ranked below 62. Therefore, the government has carried out reforms aimed at improving the quality of education by compiling various components of education. Three main issues are the core of educational innovation: curriculum innovation, improving the quality of learning, and the effectiveness of learning methods. Therefore, the government established the 2013 curriculum as the newest education program, which has undergone many revisions, the last being the 2013 curriculum revision in 2017.

As one of the Natural Sciences (IPA) family subjects, chemistry requires more understanding than memorization in the learning process, so a strategy or approach is needed in learning. This is crucial to improve students' ability to understand a chemistry concept. Therefore, the success of learning chemistry by students is determined mainly by their ability to understand the ideas that are an absolute requirement. According to Samudra et al. (2014), understanding concepts is a way to understand something that has been patterned in mind and accessed by symbols or signs orally (verbs) or in writing. Therefore, students' weak ability to understand chemical concepts can be caused by the teacher's inaccuracy in providing learning support in understanding these concepts.

In the 2013 curriculum, the teacher is one of the factors that determine a good learning process. Where the teacher is required to master the material to be delivered to students, determine approaches in the teaching and learning process, choose learning models, and manage classes properly supported by tactics and strategies. as well as select the means of support. In addition, the learning model in the 2013 curriculum must fulfil the 5M, namely Observing, Asking, Identifying, collecting data, and communicating, which is the purpose of learning models like this to make students understand learning well.

According to Mulyasa (2014), the 2013 curriculum is character- and competency-based. Therefore, playing the role of the teacher is forming the character and competence of students who must be creative in sorting and choosing and developing learning methods and materials to produce productive, creative, innovative, and efficient human resources and character. One of the components that determine the success of learning is learning outcomes. The results of learning can be known through various forms of evaluation. Examples include collecting data to know which part of the learning objectives, to what extent, and in what terms have been achieved. For educators, the results of this evaluation are beneficial for self-reflection. The results of reflection can be used to improve learning in the future. For example, based on the analysis of the results of the learning evaluation, it was found that the students found complicated materials to answer correctly. While studying chemistry in senior high school, one of the materials considered complicated and confusing for students was buffer solutions. One of the reasons is the abstract nature of the support material at the microscopic level.

Development of students' abilities in science process skills and science attitudes can be carried out with project-based learning because students are directly involved in working on the project. Students are allowed to independently construct their knowledge, produce products as the culmination of projects, and communicate the results of their projects (Siwa et al., 2013). In addition, students' self-confidence level increases in following practicums and skills in observing objects in practicums. This condition will impact increasing scores on various other KPS indicators (Suhanda & Suryanto, 2018).

A buffer solution is one of the chemical concepts where learning can use project-based learning to improve science process skills. Basic competency 4.12 (in the 2013 revised 2016 curriculum), students must make a buffer solution with a certain pH. In this lesson, there are prerequisite materials that students must master, namely the concept of equilibrium, stoichiometry, Arrhenius and Bronsted-Lowry acids, and acid and base ionization constants.

Based on the basic competency 4.12 buffer solution and given the prerequisite material that students must master; educators are required to be able to assess the abilities of students as a whole during the learning process. However, educators find that students experience difficulties when solving problems, usually caused by a lack of knowledge of the subject matter. This can be caused by misunderstandings or misconceptions regarding symbols and formulas as well as difficulties in understanding the context of the buffer solution followed by generalizing concepts and using incorrect problem-solving strategies (Yuriev, Naidu, Schembri, & Short, 2017; Parastuti, Suharti, & Ibn, 2016). Therefore, this study aimed to test the effectiveness of applying the learning model to skills and scientific process results in Buffer Solution learning materials in senior high school (SMA).

II. METHODS

This research is a research design and development of the education system. The development spectrum has been discussed by (Rusdi, 2018). The spectrum provides insight that there are four or more choices (a combination of the four types) for design and development research. For example, in development 1, the researcher constructs a theoretical basis related to constructivism theory, cognitivism theory, and others to be implemented in existing procedural solution designs. Furthermore, the researcher conducted one-on-one testing or in small groups in the class to iteratively perfect the product prototype. According to Rusdi (2018), development research 1 focuses more on compiling a solution design model that is conceptual and procedural. Then become a guideline for researchers to develop products such as learning multimedia, teaching materials, Student Worksheets (LKPD), teaching aids, learning games, learning comics, or learning models (focus on implementation syntactic procedures). This phase is identical to the so-called analysis and exploration phase proposed by McKenney and Reeves (2012). Rusdi (2018) discusses educational design and development research procedures and provides arguments about the freedom of researchers to develop procedures to be carried out if they are under the substance of the problem and the desired target.

Conceptual Model Development includes model development and product development. This study of the development of learning model procedures is included in the category of model development. Model development is carried out to build and validate a model related to education to achieve specific goals. According to Lee and Jang in Rusdi (2018), there are five types of model development research. The researcher chose the fifth model with more data source components from the validator's point of view. According to Lee., JL and Jang S in Rusdi (2018) grouped ten types of research processes to develop learning design models seen from functional, origin, source, and scheme analysis. Table 1 shows the development process.

Table 1: Procedural aspects of developing a conceptual model (Rusdi, 2018)

No	Dimensions	Component
1	Function, F	F1. Conceptual F2. Procedural
2	Origin, O	O1. Theory-driven O2. Practice-driven O1+O2. Hybrid
3	Source, S	S1. Literature S2. Internal theoretical product S3. Real life project S4. Design simulation task S5. Practitioner S6. Expert
4	Analysis scheme, A	A1. Variable or activity A2. ADDIE or related processes A3. Heuristic design pattern A4. Functions, theoretical components, or design instructions

This study uses the F2 style search procedure. This type builds a procedural learning design model with a theory and practice-driven approach that has been modified according to development needs. This F2 category includes the O1S1A2 and O2S5A1 codes. This type builds a procedural learning design model with a practice-oriented and theory-based approach. By using stages of development procedures such as 1) determining data sources, 2) collecting data, 3) analyzing data, 4) generating model ideas, and 5) describing models.

III. RESULTS AND DISCUSSION

The results obtained from this study follow the synthesis procedure which is a combination of type 1, namely F2-O1-S1-A2 (conceptual model, theory-based, sourced from literature through review, ADDIE literature or connected processes), and F2-O2-S5-A1 (procedural, practice-based, sourced from practitioners' opinions/views by linking between variables). The results obtained from this study are by following the synthesis procedure (J. Lee & Jang, 2014), which is a combination of type 1, namely F2-O1-S1-A2 (conceptual model, theory-based, sourced from the literature through ADDIE literature reviews or connected processes), and F2-O2-S5-A1 (procedural, practice-based, sourced from the opinion/view of practitioners by linking between variables). Development of scaffolding flow and worksheets for educators and students in the project-based learning model (PjBL Flipped Classroom) in improving science process skills for buffer solution materials using the Lee, J., L and Jang, S model in Rusdi (2018) by applying the stages as follows:

Define data sources

The purpose of determining the data source is to support the development of Scaffolding in the Project Based Learning (PjBL Flipped Classroom) model. The data obtained in this study used the revised 2013 curriculum. Children generally learn through interaction, so the curriculum needs to be designed to emphasize the interaction between learners and tasks according to the impact of Vygotsky's concept in. Therefore, the researcher chose KD 3.12 and KD 4.12. The 2013 curriculum requires students to independently develop the information they receive, so a constructivist learning paradigm is needed to help students overcome problems in learning. There are three emphases in constructivist theory. First, construct meaningful knowledge through the active role of students. Second, the importance of making connections between ideas to build something meaningful. Third, make connections between new ideas and information received. Constructivism learning theory is based on two theories: Piaget's and Vygotsky's. In this study, the characteristics of the students were in class XI MIPA with an average age of 16 years. Based on this age, it is known that students are included in the formal operational stage category. According to Piaget's theory in Slavin (2011), formal operations are carried out from around 11 to adulthood, where abstract and purely symbolic thinking is possible. Third, problem-solving can be done through the use of systematic experimentation. Fourth, make connections between new ideas and information received. Constructivism learning theory is based on two theories: Piaget's and Vygotsky's.

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The highest stage of intellectual development is the theory of formal operations which is the hypothetical-deductive stage of operations. Whereas Vygotsky's theory emphasizes the assistance educators can provide to students in overcoming problems that cannot be answered. The emphasis on Vygotsky's theory, namely Scaffolding or mediated learning, plays an important role in modern constructivist thinking. Zone of Proximal Development (ZPD) for students can be assisted through Scaffolding to get out of the problems that arise. Every child has something called the Zone of Proximal Development (ZPD), according to Vygotsky, is the distance between the actual level of development and a higher level of potential development. According to Vygotsky, students can reach the maximum area if they are assisted sufficiently, but if they learn without assistance, they will remain in the actual area without being able to develop to a higher level of potential development. The next problem is developing an effective and efficient scaffolding strategy so students' actual skills can be developed into potential abilities (Chairani, 2015). In this study, researchers used Fisher's scaffolding stages to develop effective and efficient strategies to help students. There are four parts to the form of Scaffolding, according to Fischer (2010), that educators can do to help students, such as Questioning (checking to understand), Prompting (facilitating the process of student cognition), Cueing (diverting students' attention to focus on more specific information, errors or partial understanding), and Explaining (explaining directly, modeling, and motivation).

In applying KD 4.12, the researcher uses the PjBL Flipped Classroom learning model, which consists of 6 stages. Project-based learning adapted from Keser and Karagoca in Hosnan (2014) consists of several steps such as; (1) Determine basic questions, (2) Design project plans, (3) Arrange schedules, (4) Monitor students and project progress, (5) Test results and (6) Evaluate experiences. Applying the PjBL Flipped Classroom model can lead to science process skills. Project-based learning is very effective in developing students' science process skills and science attitudes. The project-based learning model can improve KPS in all aspects, based on Suhanda & Suryanto's research (2018). The results of each aspect of the PPP are interrelated. For example, good observation skills affect the improvement of aspects of asking questions and predicting improvement of aspects of formulating hypotheses and designing experiments can be influenced through aspects of asking questions and predicting. Improved implementation of project work can improve skills in applying concepts and communicating results well.

Increased scientific process competence shows that project-based learning involves students in project work activities, provides opportunities for students to work independently, builds on their knowledge, and ultimately produces products and is presented (Siwa et al., 2013). In addition, students are also confident in doing practicum and demonstrating increasingly competent observation skills, thereby influencing the increase in the value of other KPS indicators (Suhanda & Suryanto, 2018). The instructional design used in this study is the instructional design of Morrison et al. (2013) which consists of 9 elements, namely (1) identifying learning needs, (2) analyzing students and the environment, (3) learning sequence, (4) learning strategies, (5) message delivery design, (6) developing teaching materials, (7) developing learning, (8) instruments evaluation, and (9) the ongoing process.

Collecting data

Review the literature from books, journals, articles, and other data sources collected in this study. Related sources are the development of scaffolding research, PjBL Flipped Classroom, KPS, and buffer solution material.

Analyze data

The data analysis stage was carried out by correlating the information obtained between Scaffolding, the PjBL Flipped Classroom model, and KPS, which were reviewed based on the characteristics of the buffer solution. The form of Questioning is rarely used in the form of explaining. Scaffolding is often used in the form of Questioning and prompting while cueing and explaining. It is used when the subject's ability is outside the Zone Proximal Development (ZPD). Based on the results of this study, the use of Scaffolding in the PjBL Flipped Classroom model was chosen based on the difficulty level of each syntax. In the PjBL Flipped Classroom application, Blumenfeld et al. in Warsono & Hariyanto (2014) explain that students try to solve important problems by 1) feeling a problem and immediately questioning it, 2) discussing ideas in a team, 3) making predictions, 4) design work plans and experiments, and 5) collect data, analyze, 6) conclude, 7) communicate their thoughts to people others, especially his teammates, 8) question the possibility of new problems appearing, 9) learn to Create artifacts as evidence of achievement. Using Scaffolding also helps students improve their science process skills. 9) learn to Create artifacts as proof of achievement. Using Scaffolding also helps students improve their science process skills. 9) learn to Create artifacts as proof of achievement. Using Scaffolding also helps students improve their science process skills.

Project-based learning effectively develops science process skills and students' attitudes toward science. Suhanda & Suryanto (2018) added that students became more confident doing practicum by demonstrating more proficient observation skills so that the score in the KPS indicator increased. According to Parmani et al. (2019), students understand that they can increase their motivation to learn, increase their creativity in creating products from the projects they are working on, and improve their critical thinking skills through activities. The buffer solution material was chosen for this study. Buffer solution material requires understanding the correct basic concepts. The basic concept of equilibrium, stoichiometry, Arrhenius and Bronsted-Lowry acids, acid and base ionization constants (Ka and Kb), and the concept of pH. In addition, students must understand the buffer solution so that an understanding of the three levels of representation: submicroscopic, macroscopic, and symbolic can be completed.

Come up with ideas

At this stage, the researcher is looking for information related to the development of Scaffolding that previous studies have developed. Researchers obtained information that previously, Scaffolding was developed in general because there was no specific scaffolding for the material. As in the research, Yuriev et al. (2017) have conducted research related to Scaffolding with the result that a workflow/assistance has been formed based on the Goldilocks Help (GH) workflow in assisting the chemistry learning process in class. However, in his research, Yuriev only provided results in scaffolding paths for chemicals in general problem-solving models, and there was no specific scaffolding assistance yet. Meanwhile, Effendi-Hasibuan's patented invention (Patent No.

000160197, 2019) creates a Systematic Scaffolding Guidance (SSG) scheme in Figure 2.6. This scheme is proven to help overcome learning difficulties experienced by students by using three stages and Scaffolding. Schemes can be applied to all learning models and have not been specifically conceptualized, such as relating them to certain chemical materials.

Based on the results of the two studies, the researcher concluded that the two studies had something in common; namely, they developed Scaffolding in general. Therefore, the researcher made a more specific path by using the buffer solution material in the PjBL Flipped Classroom model to improve science process skills and show ideal Scaffolding in each syntax of the model. In its application, researchers see the need for learning media such as LKPD, which functions as a connecting medium for the plots that have been made. Because if there are no other media, educators will find it difficult to describe the use of the scaffolding flow that has been made.

Scaffolding is closely related to dynamic assessment, where the assessment is carried out based on the difficulties faced by each student. So that the scaffolding assistance provided can accurately solve the problems or difficulties of students. Belland & evidence (2017) argues that dynamic assessment can assist educators in determining the extent to which students' skills can increase so that it will lead to success through or without Scaffolding, and adjustments are made in real-time. This opinion is consistent with the findings of Pol et al. (2010) regarding the Conceptual model of Scaffolding, which states that the assistance provided by educators to students will experience fading along with the assistance provided.

Practitioner validation

The material validation was carried out twice. The results of the first validation concluded that in terms of the material, it was good. However, it was necessary to improve the pictures and information related to the images, such as their composition, so that they were effective in increasing students' understanding of the use of buffer solutions in everyday life. This follows the opinion of Morrison et al. (2013) regarding the function of images in a lesson: decoration, representation, work steps, interpretation, and transformation. In learning, students must be guided to use pictures according to the narrative they are reading. In addition, a concrete picture of abstract content can be represented through pictures so learning messages can be optimally conveyed. The practicality of the flow and LKPD developed is assessed through practitioner/educator validation with the aim that each approach used in the scaffolding procedure in the PjBL Flipped Classroom model results in a suitability assessment and is based on the experience of the educator implementing the learning process based on the experience of the educator. The assessment was carried out by the three educators who teach at SMA N 3 Jambi City.

Based on the evaluation of the product, the results obtained are for the accuracy of the scaffolding assistance provided in the flow, and LKPD can help students in the learning process because it follows the syntax of the PjBL Flipped Classroom model. Test procedures are structured and implemented in consistent and easy-to-understand language so that the resulting product is easy to implement and accessible to as many users as possible and saves time and effort in the learning process. This greatly affects the understanding of students. The material and illustrations presented are very easy to understand because they correspond to reality and are relevant to the buffer solution material. The components needed to help solve the problem have been adapted to the 4 stages of scaffolding assistance. This can reduce the learning load to be smaller for students, but the success of its use depends on the situation, conditions, and character of the child when learning. Therefore, educators suggest more flexible or easy exemplary materials such as acids, bases, and colloids.

Based on the three educators' assessments of usability and practicality, it can be concluded that it is good. However, researchers must carry out training for further use by educators. This is what the researchers are aware of because explaining the procedures for using flowcharts and worksheets to educators is limited by time due to the activities of educators in schools. After evaluating the product by validators and practitioners, the researcher conducted a small-scale test to see the usability and accuracy of the scaffolding assistance that the researcher had designed and assessed it through dynamic assessment. Dynamic assessment can also be used for scaffolding adjustments in implementing buffer solution practicums and seeing the constraints of students. This is supported by the opinion of Belland & Evidence (2017) that educators can determine how much the ability of student’s increases without or with Scaffolding. Adjustments are made in real-time and can provide the best information about a child's learning potential. Dynamic assessment assesses thinking, perception, learning, and problem-solving through an active teaching process. The research focuses on the 6 syntaxes of the PjBL Flipped Classroom model, looks at the problems experienced in class, and finds the right help to help solve the problems at hand. Four meetings were held in this study, in which case each meeting discussed syntax. The first meeting focused more on discussing syntax 1, and determining fundamental questions, followed by explaining the buffer solution material and tasks for the next meeting. Designing project planning and arranging schedules are carried out at the second meeting of the focus and discussing syntax 2 and 3. The third focus meeting on syntax 4 monitors students and project progress. The fourth meeting discusses syntax 5 testing results and syntax 6 evaluating experience.

Conducive conditions in developing products

The design process in this development research is centred on making the scaffolding design which is the main thing to do to develop the scaffolding flow and LKPD of the buffer solution. In the design process, sources of study such as journals, books, and other sources of information are needed so that the developments made do not lead to similarities with previous research. For this reason, teamwork and a good work environment are needed in developing scaffolding products.

The work environment in developing scaffolding products will determine the results' quality. The working atmosphere towards product development always looks for the latest information related to scaffolding. An environment that is used to openly discuss findings related to scaffolding research both from within the country and abroad. A work environment that is used to motivate each other to always make changes both for individuals and in teamwork, an environment that reinforces each other so that they are always optimistic and have positive thoughts about the products that are made and spread happiness to each other for success because all difficulties must have a solution, just waiting for the right time so that problems can be solved.

In addition to a good working environment, researchers and teams need supporting technology to manufacture products. Therefore, researchers use laptops with good hardware and software specifications to produce the product. The required hardware is an Intel Core i3 processor, a 14-inch laptop LCD screen size, a Wi-Fi network, and an external mouse. At the same time, the software is the operating system (Windows 10), Microsoft Office (Word and PowerPoint), web browser (Google Chrome), internet download manager, application design (Canva), and adequate electricity supply. The development process begins with designing in Canva, converting it into a high-quality PNG, and inputting it into Microsoft PowerPoint to include writing such as material and other explanations. After it is finished, it remains to be printed.

In developing scaffolding product development, specific knowledge and skills are required that developers must have, including the developer must understand the stages of scaffolding, PjBL syntaxFlipped Classroom, science process skills, and buffer solution materials. Understand and analyze the suitability of the scaffolding stages in each PjBL model syntaxFlipped Classroom. Linking science process skills needed by students in each PjBL syntaxFlipped Classroom. Then the developer must also pay attention to the concepts and learning procedures that will be used later.

Developmental research is group research. This research cannot be carried out alone but requires members with their respective duties. For example, members in the scaffolding product development research in the form of scaffolding grooves in the PjBL Flipped Classroom model and LKPD buffer solution include developers, researchers, and three teams of experts to assess the feasibility of the product produced later. The solidity of the team in working determines the quality of the product that will be developed later to make changes both for individuals and in teamwork, a mutually reinforcing environment so that they are always optimistic and have positive thoughts about the products made and spread joy to each other for success because all difficulties must have a solution just waiting for the right time for the problem to be resolved.

Recommended Procedure

The use of grooves and LKPD products will be effective for students studying buffer solution material intended for class XI MIPA if you look at the time allocation for learning buffer solution material which is in the second semester with a period of 3 x 45 minutes. This is because there are several weaknesses in the PjBL model. The weaknesses of using the PjBL Flipped Classroom model are as follows: 1. many tools are used, 2. Students who are not good at experimenting and gathering information will experience difficulties. 3. Students are less active in group work. 4. According to Nawawi, the lack of time for students to solve problems is a weakness in using project-based learning models, and 5. Lack of funding (Parmani et al., 2019). To use LKPD, educators must understand the syntax of the PjBL Flipped Classroom, which has been prepared based on the required science process skills, here educators must also pay attention to tasks that have been divided to be carried out at home and school so that they can help educators to process time more effectively. Therefore, students and educators must work together to discover factors, innovations, and ways to improve, modify, add, or replace effective and meaningful methods in each learning process, especially in buffer solution material.

Because based on research, students still need help with each assignment given. This follows the opinion of Ansori et al. (2015), stating that studying buffer solution material requires a correct understanding of the underlying concepts. The basic concepts are the concept of equilibrium, stoichiometry, Arrhenius and Bronsted-Lowry acids, acid, and base ionization constants (Ka and Kb), and the concept of pH. In addition, in thoroughly understanding the buffer solution material, students must also understand the three levels of representation, namely the sub microscopic, macroscopic, and symbolic levels.

IV. CONCLUSIONS

The development of this research includes: (1) the scaffolding process and student worksheets by educators and students in the project-based learning model to improve science process skills in buffer solution material, (2) favorable conditions for the design and development of scaffolding flow in the project-based learning model for improving KPS (scientific process skills) in buffer solution material (3) recommends the procedure for using scaffolds in a project-based learning model to improve KPS in buffer solution material.

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