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Development of an Optimal Scaffolding Model for Problem-Based Learning in Vocational Schools in Bekasi City

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Abstract

Problem-Based Learning (PBL) facilitates student learning through group activities and self-directed learning (SDL) to formulate problems related to the competencies to be achieved. The problems collaboratively formulated by all group members are studied in search of solutions. The problems provided by the teacher are unstructured, meaning there is not just one solution but several potential alternatives. SDL requires various types of diligence or student skills. Students who succeed in learning through PBL largely depend on the amount of appropriately personalized support they receive and their confidence in overcoming their shortcomings with that support (Smith & Cook, 2012). However, vocational school (SMK) teachers, especially in technology and engineering, have not yet found ways to provide scaffolding to students learning through PBL to face their optimal challenges. This situation arises because vocational school teachers generally position themselves as facilitators in PBL learning rather than forming a PBL tutor team. This research aims to develop a scaffolding design for SMK students in technology and industry to tackle optimal challenges. Scaffolding focuses on enhancing students' problem-solving skills by providing timely support (Wood et al., 1976). The formative evaluation phase is divided into three parts: one-on-one evaluations by experts and learners, small group evaluations, and field trials. The results of the one-on-one evaluations by experts, consisting of content and media specialists, yielded average scores of 88.49% and 95.42%, respectively, both rated as very feasible. This indicates that the learning materials for the Scaffolding of Optimal Challenges in the PBL subject of Programming and Microcontroller Applications are indeed suitable for use in the learning process within Technology and Engineering SMK environments in Bekasi City.

Keywords: *PBL Strategy, Scaffolding, Programming and Microcontroller Applications*

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INTRODUCTION

The tasks given in problem-based learning (PBL) are unstructured tasks. The solutions to these tasks require a self-directed learning (SDL) process. SDL requires various types of attentiveness or skills from the learners. Students who successfully learn through PBL largely depend on the amount of personalized support they receive and whether they believe they can overcome their

shortcomings with that support (Smith & Cook, 2012). The optimal challenge of a task for students depends on how they perceive their mastery of the skills required to complete the task (Durik, Hulleman, & Harackiewicz, 2015). In teacher-centered learning processes, the teacher is responsible for directing the difficulty of the task through the development of sequences and problem selection. However, in problem-based learning (constructivist curriculum), the lecturer loses much of their ability to effectively set the optimal level of challenge for each student, as students need to tackle unstructured tasks through self-directed learning (Hmelo-Perak & Barrows, 2015). According to Hmelo et al., properly implemented PBL involves extensive student support in the form of scaffolding, which helps students experience success even when facing learning difficulties (Hmelo-Silver, Duncan, & Chinn, 2007). Why is the implementation of problem-based learning not always successful across different fields of study? One possible explanation is that PBL originated in medical schools, which serve a population of highly motivated and independent learners who also have a specialized knowledge base and relatively homogeneous advanced problem-solving skills (Barrows, 1996). Unlike medical students, students in other disciplines, such as Electronic Engineering students, not only lack the required knowledge and skills but may also be unmotivated by problem-based learning or may not receive adequate support from their instructors (Torp & Sage, 1998). Data from the learning outcomes of Electronics Circuit Application students at SMK Negeri 7 Bekasi show that their average learning score is 33% above average (Arum, 2023). The question is, how can we provide support to students in problem-based learning to overcome the challenges they face, including a lack of specialized knowledge, problem-solving skills, self-directed learning, and collaborative skills, to improve their performance? This study aims to design scaffolding support for vocational students in technology and industry to face optimal challenges. Scaffolding focuses on the development of problem-solving skills by providing timely support (Wood et al., 1976). The researchers will examine this based on Expectation-Value Theory (EVT) by Eccles et al. (1983) as a model to predict and understand individual motivation for behavior choices related to performance. The Self-Determination Theory (SDT) (Ryan & Deci, 2000b) assumes that humans are inherently motivated to develop a "more complex and unified sense of self" (Ryan & Deci, 2002). At this point, individuals inherently desire to know, learn, and seek knowledge and values (Niemiec & Ryan, 2009).

RESEARCH METHOD

Research and development methods quoted from the book: The Systematic Design of Instruction by Dick, Walter., Carey, Lou., and Carey, James O. (2005), which was adapted as Steps of Systems Approach Model of Educational Research and Development by Gall, Meredith, D., Gall, Joyce, P. and Borg, Walter R. (2007:590), the entire instructional design process of Dick, Carey and Carey (2005) is fully adapted as a research and development model.

RESULT AND DISCUSSION

Result

The expert assessment of the content obtained a total score of 110, and with the percentage calculation, the result was 88.49% of the maximum total score of 100%. It can be concluded that the learning media, the book Scaffolding for Optimal Challenges in PBL Learning of Programming and Microcontroller Applications, can be categorized as highly feasible without revisions, as shown in Table 1.

Table 1. Percentage of Expert Content Evaluation

No.	Evaluation Aspect	Average Score	Score Obtained	Maximum Score	Percentage
1	Dimension of Learning Clarity	4,58	55	60	91,67%
2	Dimension of Impact on Students	5	5	5	100%
3	Dimension of Learning Feasibility	3,4	17	25	68%
4	Technical Dimension	4,71	33	35	94,28%
	Overall Average				88,49%
	Total Score Obtained				110
	Maximum Total Score				125
	Category				Highly Feasible

The expert assessment of the media obtained a total score of 103, and with the percentage calculation, the result was 95.42% of the maximum total score of 100%. It can be concluded that the learning media, the book Scaffolding for Optimal Challenges in PBL Learning of Programming and Microcontroller Applications, can be categorized as highly feasible without revisions, as shown in Table 2.

Table 2. Percentage of Expert Media Evaluation

No.	Evaluation Aspect	Average Score	Score Obtained	Maximum Score	Percentage
1	Dimension of Learning Clarity	4,58	55	60	91,67%
2	Dimension of Impact on Students	5	5	5	100%
3	Dimension of Learning Feasibility	5	25	25	100%
4	Technical Dimension	4,5	18	20	90%
	Overall Average				95,42%
	Total Score Obtained				103
	Maximum Total Score				110
	Category				Highly Feasible

This research produces a conceptual model of Optimal Challenge Scaffolding for Programming and Microcontroller Applications. A conceptual model is a verbal description of a particular view of reality (Richey R, Klein J, 2011). In general, optimal challenge scaffolding in PBL (Problem-Based Learning) is academic learning assistance provided by the teacher as a facilitator and tutor to students, enabling effective improvements in individual or group learning processes. Every learning model, including the optimal challenge scaffolding model, has syntax, social systems, reaction principles, and support systems. In PBL learning with optimal challenge scaffolding, teachers are involved in preparing support systems, learning strategies, and instructional

materials. The concept of optimal challenge scaffolding in PBL for the Programming and Microcontroller Applications subject is illustrated in Figure 1.

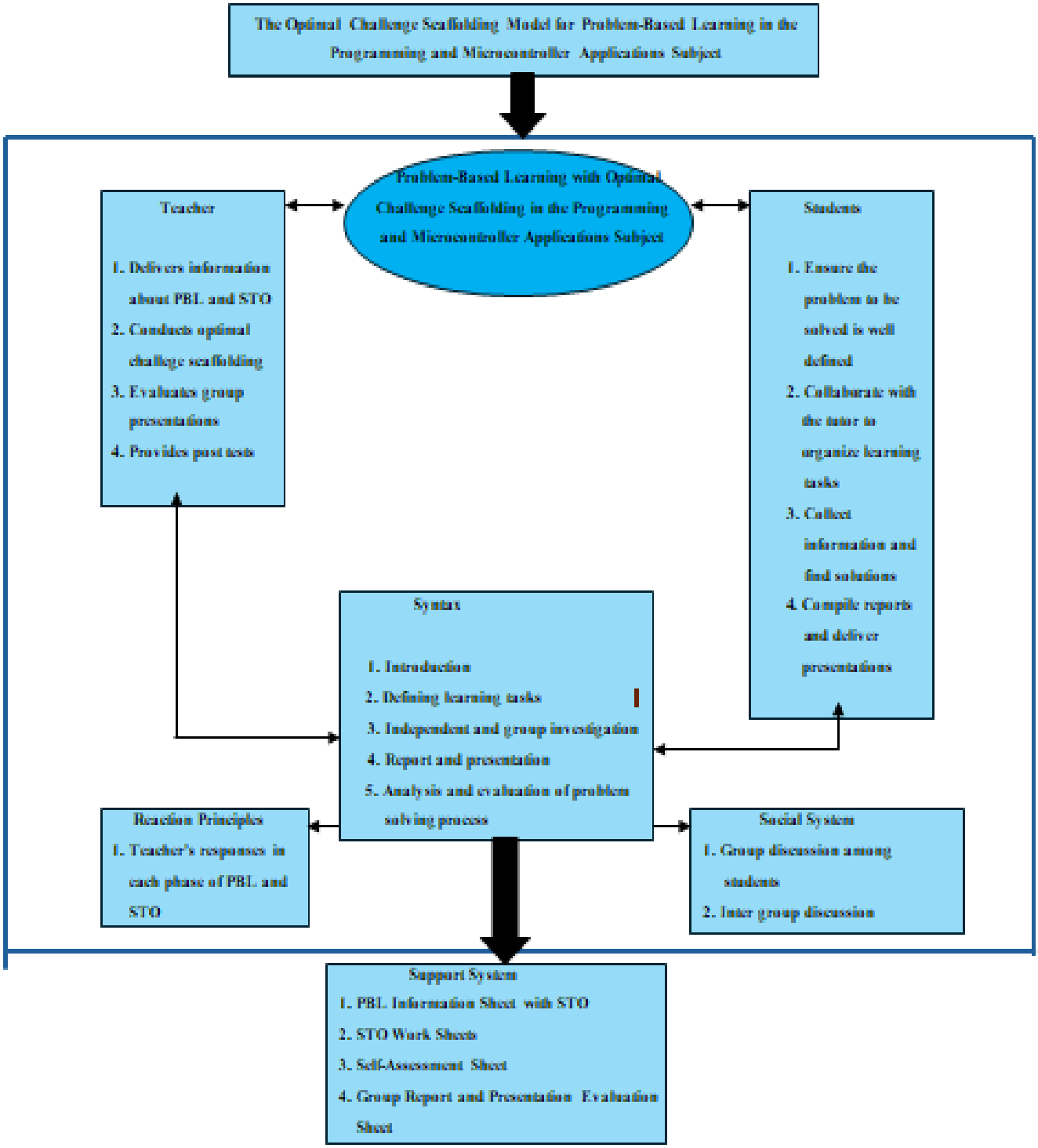

Figure 1. Conceptual Model of Optimal Challenge Scaffolding in Programming and Microcontroller Applications

DISCUSSION

Based on the research results, it appears that almost all dimensions in the formative evaluation by content and media experts indicate that the learning media, the book Scaffolding for Optimal Challenges in PBL Learning of Programming and Microcontroller Applications, is highly feasible for use in the learning process in Technology and Engineering Vocational High Schools in Bekasi City. This aligns with the view that scaffolding focuses on developing students problem-solving skills by providing timely support (Wood et al., 1976). The role of scaffolding has expanded to include enhancing content knowledge and other skills, such as self-directed learning and argumentation skills (Belland, 2010; Kek & Huijser, 2011; Leary et al., 2012). Scaffolding also plays a role in increasing motivation, including self-improvement (Belland et al., 2013; Bixler, 2007; Tuckman, 2007). Students motivation and self-confidence can be strengthened or weakened for various reasons, and different types of scaffolding should be provided to students according to their current situations (Belland et al., 2013). For students who struggle with problem solving, scaffolding is needed to enhance their understanding of content knowledge (Hannan, Land, & Oliver, 1999).

In the optimal challenge scaffolding for the Programming and Microcontroller Applications subject (STO PAM), the teacher explains the PBL learning process and the tasks to be completed by students both individually and in groups. After students form groups and understand the problem to be solved, they are asked to prepare the necessary logistics. At this stage, the teacher uses concept scaffolding and motivational scaffolding. During the learning process, students work in groups to collect various pieces of information related to the solution, utilizing both physical sources such as books from the school library and digital resources in the school computer laboratory. The challenge faced by students at this point is the difficulty in understanding the problem statement, which is framed in an open-ended manner. This requires the use of strategy scaffolding and metacognitive scaffolding to help students navigate through the problem-solving process.

CONCLUSION

The formative evaluation stage is divided into three parts: one-to-one by expert and by learner, small group evaluation, and field trial. The results of the one-to-one by experts, which included content and media experts, showed average scores of 88.49% and 95.42%, respectively, with a rating of highly feasible. This means that, from both the content and media perspectives, the learning material Scaffolding for Optimal Challenges in PBL Learning of Programming and Microcontroller Applications is highly suitable for use in the learning process in Technology and Engineering Vocational High Schools in Bekasi City.

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