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# THE ROLE OF SCAFFOLDING IN IMPROVING PRESERVICE ELEMENTARY SCIENCE TEACHERS' SKILLS ON IMPLEMENTING INQUIRY-BASED LEARNING

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**ABSTRACT**

Inquiry-based learning is considered as an effective learning pathway for teaching science, but unfortunately, elementary preservice science teachers still have an inadequate understanding of inquiry-based learning. This study investigated the role of scaffolding as a supporting method for improving preservice elementary science teachers' understanding of inquiry-based learning and their skills in implementing inquiry-based learning through peer teaching. Results suggested that scaffolding improves preservice elementary science teachers' understanding of and skills in implementing inquiry-based learning because features in scaffolding facilitate understanding and teaching skills improvement.

***Keywords***: preservice elementary science teachers; inquiry-based learning; scaffolding; teaching skill

**ABSTRAK**

Pembelajaran berbasis inkuiri dianggap sebagai jalur pembelajaran yang efektif untuk mengajarkan sains, namun sayang, calon guru IPA SD masih memiliki pemahaman yang tidak memadai tentang pembelajaran berbasis inkuiri. Penelitian ini menyelidiki peran *scaffolding* sebagai metode pendukung untuk memperbaiki pemahaman calon guru IPA SD tentang pembelajaran berbasis inkuiri dan keterampilan mereka dalam mengimplementasikan pembelajaran berbasis inkuiri melalui *peer teaching*. Hasil menunjukkan bahwa *scaffolding* memperbaiki pemahaman calon guru IPA SD tentang dan keterampilan mereka dalam mengimplementasikan pembelajaran berbasis inkuiri karena fitur-fitur *scaffolding* memfasilitasi perbaikan pemahaman dan keterampilan mengajar.

**Kata kunci**: calon guru IPA SD; pembelajaran berbasis inkuiri; *scaffolding*; keterampilan mengajar

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## INTRODUCTION

National Research Council considers inquiry based teaching and learning as an effective pathway for teaching science (National Research Council, 2000). Studies result collectively support the notion that inquiry-based learning resulted in better learning (Minner, Levy, and Century, 2010; Alfieri, Brooks, Aldrich, and Tenenbaum, 2011; Furtak, Seidel, Iverson, and Briggs, 2012). Since the implementation of the 2013's curriculum that emphasizes the scientific learning approach (Indonesia National Education Standard Agency, 2016), skill to implement inquiry-based learning are necessary for elementary science teachers in Indonesia. The benefits and necessity of implementing inquiry-based learning are, unfortunately, is not reflected in preservice science teacher's ability to conduct inquiry-based learning.

Windschitl, Thompson, and Braaten (2008) study showed that preservice teachers could not make sense of science inquiry, are not familiar with the epistemic bases of science, and do not possess sufficient content knowledge. Educational program also have not facilitated preservice teachers in understanding the importance of inquiry-based learning (Soprano and Yang, 2013). Furthermore, Seung, Park, and Jung (2014) found that preservice elementary science teachers misconnected or failed to connect learning activity with its inquiry features. Indeed, this condition raises understandable concern because understanding inquiry-based science learning is connected to its implementation (van Driel, Beijaard, and Verloop, 2001; Rop, 2002; Ozel and Luft, 2013). If teachers mastered the principles of inquiry-based learning and have experiences in practicing it, it is highly likely that she/he will implement it in their classroom (Morrison, 2014).

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Scaffolding has been used to support learners' inquiry process (see D'Costa and Schlueter, 2013; Bjonness and Kolst, 2015). By scaffolding, teachers can make essential features of the inquiry process explicit, reduce cognitive load, and provide students with the opportunity to formulate creative and independent solutions (Bjonness and Kolst, 2015). Scaffolding is commonly associated with Zone Proximal Development (ZPD) theory (Vygotsky, 1978), but scaffolding was proposed initially by Wood, Bruner, and Ross (1976) as a metaphor for adult's role in children's learning. Adults, they said, play a role as a temporary support system so that children can finish the task that they might not complete otherwise (Wood et al., 1976).

Through the years, definitions of scaffolding have been understandably varied. Van de Pol, Volman, and Beishuzen (2010) summarized common characteristics of available definitions into a conceptual model with three key features: (1) Responsiveness, tailored, adjusted, differentiated, titrated, or calibrated support (contingency), (2) Decreased amount of support overtime according to students' development and or competence, and (3) Transfer of learning responsibility from teachers' to students.

The study of scaffolding in preservice science teachers' educational program is still limited, and study on improving preservice elementary science teachers' skills in implementing inquiry-based learning is currently scarce. Therefore, scaffolding was used in this present study to improve preservice elementary science teachers' understanding and skills in implementing inquiry learning.

## METHOD

The study was conducted in one of private university in Majalengka-West Java, Indonesia. This one group pretest-posttest design study investigated 34 preservice elementary science teachers' skills in composing an inquiry-based lesson plan and teaching it accordingly. To assist preservice elementary science teachers' (henceforth will be addressed interchangeably with students) in planing and teaching science-based inquiry model, supports were made through a series of scaffolding (Table 1). Students' understanding of inquiry-based learning was evaluated before and after scaffolding by pretest-posttest, and improvement was recorded as normalized gain (N-gain or g).

In understanding the role of scaffolding for helping the students' in teaching based on the inquiry model, their skills before and after scaffolding were evaluated. The quality of the lesson plan was assessed based on six aspects (learning goals/outcomes, indicators' breakdown, materials, flow/steps, media, and evaluation) in a four scale evaluation rubrics (0-4). Teaching skills were evaluated based on students' skills in seven aspects (opening the lesson, attitude while teaching, content mastery, learning flow and steps, learning media, learning evaluation, and closing the lesson). Students' skills were also categorized according to Teacher Inquiry Rubric (Nugent, Kunz, Pedersen, and Houston, 2012): 1) Pre Inquiry (no evidence of inquiry approach in their instruction), 2) Developing Inquiry (instruction addresses inquiry topic or construct), 3) Proficient Inquiry (instructtion can be considered as guided inquiry with explicit/didactic guidance), and 4) Exemplary Inquiry (instruction can be considered as guided inquiry with scaffold guidance, high quality guided inquiry).

**Table 1**. Efforts in Assisting Preservice Elementary Science Teachers to Implement Inquiry-based Learning

| Activity | Stage |
|---|---|
| Provide characterization of inquiry learning model and on how to compose lesson plan based on inquiry learning model. | Preliminary |
| Assigning preservice teachers to compose lesson plan without guidance | Scaffolding 0 |
| Giving feedback on the lesson plan (verification and clarification) | Scaffolding I |
| Supporting the students by providing necessary guidelines such as lesson plan format and lesson plan evaluation rubric to make necessary revision in their lesson plan | Scaffolding II |
| Supporting the students by providing necessary guidelines such as the targeted learning outcomes, core content analysis, and on how to make inquiry-based worksheet | Scaffolding III |
| Providing lesson plan evaluation rubric so that preservice teachers can implemented the lesson plan into teaching (peer teaching) | Scaffolding IV |
| Assisting preservice teachers' in reflecting their teaching (peer teaching) | Scaffolding V |

## RESULTS AND DISCUSSION

### Preservice Elementary Science Teachers' Understanding of Inquiry-based Learning

Pretest results showed that preservice elementary science teacher's preliminary understanding of inquiry-based learning was below 65 points threshold and the deviation standard was relatively high (55.6 ± 12.6), which indicated that their understanding was still insufficient. In the pretest, 85.3% of students were unable to explain what constitutes inquiry-based learning. Seung et al. (2014) found that preservice elementary science teachers misconnected or failed to connect learning activity with its inquiry features in which they tend to interpret feature of inquiry teaching too broadly. Lee and Shea (2016) found results in a similar vein; preservice teachers also had a simplistic view of inquiry-based teaching. Posttest results indicated that improvement happened after scaffolding in which the average test score increased by almost 28 points, and the understanding gap between students was narrowed down (83.5 ± 6.8). Overall improvement amounted to 0.6 (average normalized gain), categorized as a medium improvement (Hake, 1998).

### Preservice Elementary Science Teachers' Skills in Composing Lesson Plan and Teaching Inquiry-based Science

Six aspects were considered in evaluating the lesson plan: learning goals, breakdown of indicators, learning materials, learning flow or steps, learning media, and learning evaluation. The average overall lesson plan score improved from 62.5 to 82.5 after scaffolding. Results showed that all lesson plan aspects improved after scaffolding with highest improvement for learning flow/steps and learning materials (0.85 and 0.72 points, Figure 1). Before scaffolding, learning steps and materials had not been arranged systematically and had not reflected inquiry steps. After providing necessary guidelines such as the targeted learning goals, core content analysis, and making inquiry-based worksheet (Scaffolding III), materials in the lesson plan have been arranged systematically, and each learning step has been efficiently designed.

In terms of teaching skills, preservice elementary science teachers improved their skills in six out of seven aspects: opening the lesson, attitude while teaching, content mastery, learning flow and steps, learning evaluation, and closing the lesson (Figure 2). Unfortunately, their skills in using learning media remain unchanged after scaffolding. Improvement in opening and closing the lesson was by 0.70 points and 0.68 points, respecttively. Content mastery, attitude while teaching, learning steps, and learning evaluation were also improved, but the improvement only amounted to 0.10-0.33 point range.

Preservice elementary science teachers' skills in conducting inquiry-based learning were categorized into No Inquiry (NI), Developing Inquiry (DI), Proficient Inquiry (PI), and Exemplary Inquiry (EI) with EI considered as high-quality inquiry-based instruction (Nugentz et al., 2012). If there were no evidence of inquiry approach in the instruction, preservice teachers teaching skill was categorized as No Inquiry (NI), and in the pre scaffolding stage, 28.3% preservice science teachers were classified in this category. Preservice teachers in this category focused on time allotment or teaching materials, and they tended to set aside essential steps in an inquiry activity. Improvement was found after scaffolding in which there were none of the preservice teachers categorized in the NI category. The percentage of instructional design, which addressed inquiry content or construct but mainly still in direct didactic (Developing Inquiry-DI) also decreased rapidly, with only 9.3% preservice teachers considered in this category after scaffolding. Almost half (45%) of preservice elementary science teachers reached Exemplary Inquiry (EI) after scaffolding, in which they were already able to use experiences and or feedback to assist their students in performing inquiry skills. Overall, the percentage of preservice teachers' reaching EI skill level was progressively improved, from 4.7% in pre scaffolding to 45% in post scaffolding (Table 2).

In terms of inquiry skills, preservice teachers still unable to help their students in formulating inquiry-based questions even after scaffolding. They were only able to compose definitive questions and unable to help their students in formulating questions that will elicit inquiry activity. This finding is in line with Saribas (2015) study which found that 50.80% of preservice elementary teachers tended to ask level 1 (knowledge) questions, and only 4.76% asking questions at higher-level thinking.

**Table 2**. Preservice Elementary Science Teachers' Teaching Skill and Categorization Before and After Scaffolding

| Skills Construct | Step in Inquiry Model | Pre Scaffolding (%) | | | | Post Scaffolding (%) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | NI | DI | PI | EI | NI | DI | PI | EI |
| Question | Application | 14 | 72 | 14 | - | - | 42 | 58 | - |
| Investigate | Exploration | 14 | 86 | - | - | - | - | 72 | 28 |
| Collect and Record Data | Exploration | 28 | - | 72 | - | - | - | 72 | 28 |
| Explain | Explanation | 86 | - | - | 14 | - | - | 58 | 42 |
| Communicate | Elaboration | 14 | 58 | 28 | - | - | - | 14 | 86 |
| Apply | Application | 14 | 58 | 14 | 14 | - | 14 | - | 86 |
| | Average | 28.3 | 45.7 | 21.3 | 4.7 | - | 9.3 | 45.6 | 45 |

Note: No Inquiry (NI), Developing Inquiry (DI), Proficient Inquiry (PI), and Exemplary Inquiry (EI)

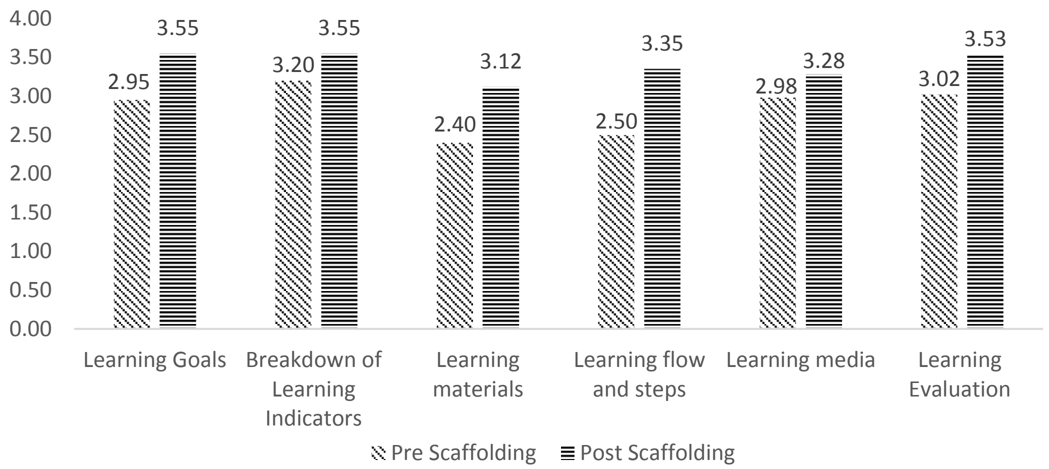


**Figure 1.** Preservice Elementary Science Teachers' Lesson Plan Average Score Before and After Scaffolding

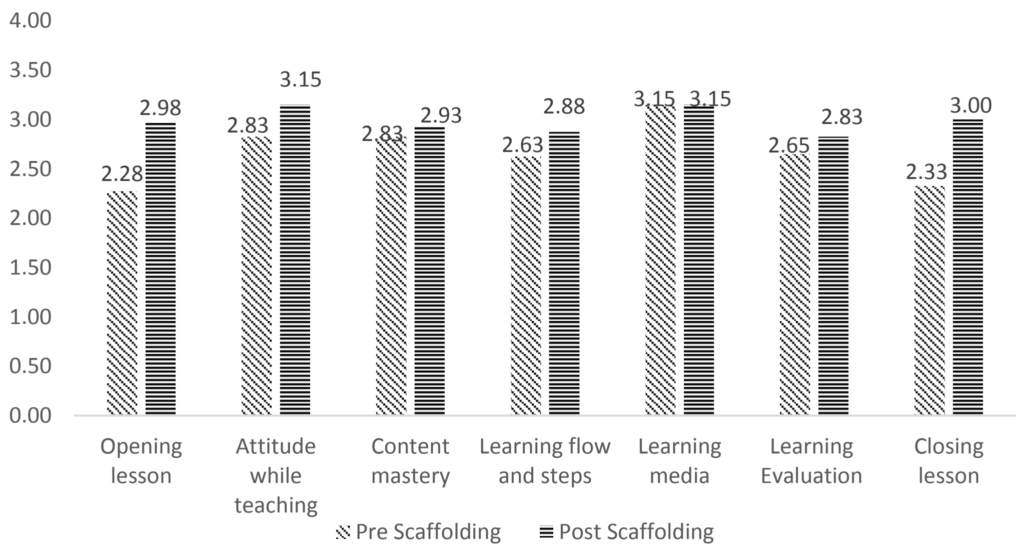


**Figure 2.** Preservice Elementary Science Teachers' Peer Teaching Score Before and After Scaffolding

### Scaffolding and Preservice Elementary Science Teachers' Teaching Skills Improvement

Scaffolding has been proven to be effective from students' cognitive, affective, and metacognitive standpoint (van de Pol et al., 2010). To address scaffolding roles in learning improvement, one should consider three main features of scaffolding: contingency based on students' response and needs, gradual support withdrawal over time, and responsibility transfer from teachers to students (van de Pol et al., 2010). In his classic Zone Proximal Development (ZPD) theory, Vygotsky (1978) stated that there is a distance between what learners currently can do with what they can do when given support, i.e., under guidance or collaboration with more capable peers. In this study, guidance was based on preservice elementary science teachers' initial understanding of and skills in implementing inquiry-based learning.

By understanding and analyzing students' responses and what they need based on their response, the instructor could plan an intervention to improve what the students' needs to improve. Van de Pol, Volman, Oort, and Beishuizen (2014) study implemented The Model of Contingent Teaching (MCT), and their result indicated that a series of contingent activity cycle (evaluate-provide supports based on evaluation data-evaluate students' new condition) improved teaching quality. From scaffolding I until Scaffolding V (SI-SV) in this study, the instructor continuously gave necessary feedback and guidance to support the students on completing the lesson plan and transforming lesson plan into teaching activity.

Supports for lesson plan and teaching skills improvement are also provided via peer collaboration. Along with scaffolding activity, peer interaction and feedback gave preservice elementary science teachers opportunities to correcting their understanding and perfecting their skills in design and implement inquiry-based learning as supported by previous authors (Watters and Ginns, 2000; Soprano and Yang, 2013; Cinici, 2016). Those studies proved that collaborative learning was useful in developing students' conceptual and pedagogical knowledge as well as improving students' science teaching self-efficacy. In terms of self-efficacy, it is also important to note that in the preliminary stage (Table 1), preservice teachers admitted that they did not have confidence in implementing inquiry-based learning. However, along with scaffolding activity and interaction with instructor and their peers, they gradually built their sense of self-efficacy.

Active participation and learners' own responsibility to discover knowledge are the key features of inquiry-based learning (de Jong and van Joolingen, 1998). By gradually withdrawn support over time and transferring learning responsibility from teachers (instructor) to students (preservice teachers), learning will move into a more constructivist learning setting. Lindgren and Bleicher (2005) study in 49 preservice elementary teachers showed that a constructivist-oriented setting improved conceptual understanding and increased self-efficacy. Similarly, Varma, Volkmann, and Hanuscin (2009) study in 40 preservice elementary science teachers proved that learning in a constructivist environment not only develops their understanding of inquiry-based science instruction but also develops an appreciation for the benefits of teaching and learning science through inquiry.

Overall improvement in preservice teachers understanding of and skills in teaching inquiry-based learning showed that scaffolding was effective, as Nusu (2014) also found. However, both Nusu (2014) and this study found that improvement was categorized as moderate which indicated that scaffolding was not optimal yet. Some aspects of instruction, whether in the lesson plan item or teaching quality indicators, only narrowly improved or even remained unchanged. Loucks-Horsley and Matsumoto (1999) aptly stated that improving teachers' teaching skills is difficult and time-consuming, so that understandably, scaffolding has not improved some aspects yet. Nevertheless, this study has proved beneficial and potential implications of scaffolding in preservice elementary science teachers' educational programs.

## CONCLUSIONS

Scaffolding improves preservice elementary science teachers' skills in implementing inquiry based learning because scaffolding features facilitate understanding and teaching skills improvement. Several aspects of preservice elementary science teachers' understanding and teaching skills were persistent to improvement due to time constraints in implementing the scaffolding approach. Appropriate time allotment for scaffolding to achieve high-level improvement can be considered as an interesting area for future research.

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