ESTEEM Journal of Social Sciences and Humanities
Vol. 5, No. 2, 15-33, September 2021
https://ejssh.uitm.edu.my

Facilitator's Scaffolding Strategies in a Design-based Learning Context

Yee Ling Lee[1] and Meng Yew Tee[2]

[1]Research Centre for Future Learning, School of Education, Taylor's University, Malaysia
[2]Faculty of Education, University of Malaya, Malaysia.
**Corresponding author: [1]yeeling.lee@taylors.edu.my*

ABSTRACT

ARTICLE HISTORY

Received:
18 June 2021
Accepted:
05 August 2021
Published:
30 September 2021

KEYWORDS

Adaptive Scaffolding
Facilitator
Scaffolding Strategies
Design-based Learning

Design-based learning (DBL) is a pedagogy grounded in inquiry towards generating artefacts to solve a real-life issue through an iterative engineering design process. Completing a design task is challenging. Scaffolding is necessary for supporting student learning in a DBL context. However, a review of the literature revealed that there are still significant implementation issues related to scaffolding student learning in this context. The roles played by facilitators in scaffolding student learning in a DBL context are also under-researched. This study aimed to investigate facilitator's scaffolding strategies which could be used to help students integrate knowledge in a DBL context. This study involved a class of 27 Form 1 students in a national school. The students learned how to integrate knowledge from Science, Technology, Engineering, Arts and Mathematics (STEAM) subjects to design and construct a water filter. They were scaffolded by the facilitator throughout the implementation of this design task. Video recordings, student interviews and researcher's notes were used for data collection. Several vignettes were presented to illustrate how these scaffolding strategies were used to help students integrate knowledge. The research findings showed that the facilitator used various types of scaffolding strategies to support student learning based on their emerging learning needs. The scaffolding strategies were categorised into six types in terms of cognitive, linguistic, metacognitive, motivational, social, and strategic scaffolding. This study highlighted how multiple facilitator's scaffolding strategies could work as a system to help students develop a coherent understanding of the design task. This study provides guidance for teachers in pre-designing scaffolding into their instructional practice. This study also opens new lines of research which establish connections between application of scaffolding knowledge integration and interdisplinary learning context.

e-ISSN 2600-7274

1. INTRODUCTION

Scaffolding refers to temporary support provided by more capable individuals to help students move progressively towards independent learning (Maybin, Mercer, & Stierer, 1992). Two broad categories of scaffolds are fixed and adaptive scaffolds (Azevedo, Cromley, Winters, Moos, & Greene, 2005) or hard and soft scaffolds (Saye & Brush, 2002). Hard or fixed scaffolds are static support planned in advance of implementing a lesson (Azevedo et al., 2005; Saye & Brush, 2002). Soft or adaptive scaffolds are dynamic and situational support provided to students based on their progressive development in learning (Azevedo et al., 2005; Saye & Brush, 2002). Adaptive scaffolds are essential in a constructivist learning environment, such as design-based learning (DBL) (English, 2016; Puente, Eijck, & Jochems, 2013a, 2013b).

However, in the research on DBL, the roles played by facilitators are not well researched (Puente, Eijck, & Jochems, 2013a). A synthesis of the existing literature shows that facilitators use six main types of scaffoldings to support student learning: cognitive, linguistic, metacognitive, motivational, strategic, and social scaffolding (Belland, 2017; Belland, Kim, & Hannafin, 2013; Baxter & Williams, 2010; Smit & Eerde, 2013). Yet, there is a lack of research in identifying how facilitators can adopt these different types of scaffoldings in a DBL classroom (Puente et al., 2013a). Furthermore, there are still many open questions about how different types of teacher's scaffolding strategies interact and work as a system to support student learning. This study aimed to close these research gaps by exploring facilitators' scaffolding strategies to help students integrate knowledge in a DBL context.

This study has practical implications on teaching and learning. It can extend facilitators' understanding of students' different learning needs in constructivist learning environments such as DBL. This study can also help facilitators plan different types of scaffolding strategies to cater to their students' diverse learning needs to explore their investigation path. Besides, the research findings can provide an insight into how different scaffolding strategies work synergistically to support student learning in a DBL context.

2. LITERATURE REVIEW

2.1 Types of Scaffoldings

Research on scaffolding student learning in inquiry-based learning environments divided scaffolding into six main types: cognitive, linguistic, metacognitive, motivational, strategic, and social scaffolding (Belland, 2017; Belland, Kim, & Hannafin, 2013; Baxter & Williams, 2010; Smit & Eerde, 2013). Making a distinction between different types of scaffolding does not mean that scaffolding strategies fall neatly into one specific category. Indeed, researchers recognise that students need scaffolding from the cognitive, language, social, and emotional aspects. Cognitive scaffolding helps students construct cognitive structures such as identifying evidence, analysing and interpreting data and, justifying the proposed solution (Baxter & Williams, 2010). It also helps students focus on *"things to consider"* (Belland, 2017, p. 109) when they solve a problem. Cognitive strategies such as highlighting critical features (Baumgartner & Reiser, 1998; Penner, Lehrer, & Schauble, 1998), providing hints (Cunningham & Lachapelle, 2016; Penner et al., 1998) and, unpacking scientific knowledge underlying a design solution can help students narrow down alternatives to focus on a more productive solution (Hmelo, Holton, & Kolodner, 2000). Linguistic scaffolding helps students achieve desired academic language output (Smit & Eerde, 2011). For instance, facilitators help students use correct scientific terminology to explain their design solutions (Puente et al., 2013a), restate their correct utterances and, reformulate their answers using precise terms (Smit & Eerde, 2013).

Metacognitive scaffolding helps students self-reflect on their knowledge and skills and monitor their progress (Belland, 2017). Asking reflective questions (Hmelo et al., 2000; Penner et al., 1998) can trigger students to reflect on their design solutions. Motivational scaffolding triggers students' interest and enhances their motivation to keep them engaged in the activities (Belland, Kim, & Hannafin, 2013). This can be achieved by giving students autonomy to make design decisions (Puntambekar & Kolodner, 2005), developing a shared task goal, and establishing task value (Belland et al., 2013; Puntambekar & Kolodner, 2005). These strategies can develop students' ownership of a design task (Belland et al., 2013).

Learning in a DBL context is collaborative in nature (Puente et al., 2013b). Social spaces allow students to share ideas with their peers and support or rebut each other's ideas to co-construct knowledge (Puntambekar & Kolodner, 2005). Thus, social scaffolding is necessary to guide students to work with each other (Baxter & Williams, 2010). Teachers need to highlight group rules or bootstrap collaborative learning skills to help students work with their peers (Baxter & Williams, 2010). Strategic scaffolding suggests strategies or processes students can use to solve a design task (Belland, 2017). This strategy opens an opportunity for students to apply their knowledge, revise and modify their plans based on feedback received for better outcomes (Belland, 2017).

Some studies have investigated facilitator's scaffolding strategies in light of a particular type of scaffolding. For instance, Mackiewicz and Thompson (2014) reported that the tutors in their study used motivational scaffoldings such as reinforcing student's ownership and control over their work, using humour, and showing empathy towards their students' unpleasant learning experience. In terms of cognitive scaffolding, the tutors read aloud the students' drafts, linked new knowledge to a prior topic, prompted and hinted at the students (Mackiewicz & Thompson, 2014). In a research that explored social scaffolding, Baxter and Williams (2010) found that teachers used questions to invite responses from the students and encourage them to look for alternative solutions during whole-class discussions. However, research into the six aforementioned scaffoldings and how they work together to support learning is scarce. In this study, we examined how the facilitator scaffolded learning using different scaffolding strategies that were chosen based on the student's emerging learning needs in a DBL environment.

2.2 Scaffolding Design-based Learning

Design-based learning (DBL) is an instructional approach in which students solve ill-structured, real-life issues through an iterative cycle of the engineering design process (English & King, 2015; Puente et al., 2013b). The design processes involve identifying design problems, designing, testing, justifying, and redesigning a design solution (English & King, 2015; Puente et al., 2013b; Puntambekar & Kolodner, 2005). DBL emphasises making connections between design activities, concrete artefacts, and relevant conceptual knowledge (English & King, 2015). However, students tend to treat DBL tasks as craft activities and pay less attention to the concepts underlying their designed artefacts (Puntambekar & Kolodner, 2005). For example, Berland, Steingut, and Ko (2014) found that students could suggest multiple solutions for designing and refining their designs, but they did not associate them with disciplinary knowledge. Students also face many challenges such as obtaining unexpected design outcomes, misinterpreting data and, identifying imprecise variables which affect their results (Baumgartner & Reiser, 1998). DBL can only become a productive context for student learning if appropriate facilitator scaffolds are provided to them (English & King, 2015; Hmelo et al., 2000; Puente et al., 2013a, 2013b; Puntambekar & Kolodner, 2005). For instance, the students in the research by Puntambekar and Kolodner (2005) were able to develop scientific reasoning and argumentations when they were involved in designing a solution to solve a real-world corrosion issue, with the support from hard scaffolds (i.e., written prompts) and facilitators. In a study by Hmelo et al. (2015), young students were able to learn the complex scientific ideas about the respiratory system as they were constructing an artefact resembling human lungs with support from the facilitator.

Previous studies have indicated that facilitators play a pivotal role in supporting student learning in a DBL learning context (Penner et al., 1998; Puente et al., 2013a; Puntambekar & Kolodner, 2005). Scaffolding maximises the full affordances of DBL for fostering students' knowledge construction, metacognition skills, and scientific reasoning (Puntambekar & Kolodner, 2005). For example, facilitators ask appropriate questions to help students notice and connect knowledge from multiple disciplines to develop a design solution (English & King, 2015; Hmelo et al., 2000; Penner et al., 1998). Facilitators also stimulate students' inventive thinking by focusing their attention on main design issues and making connections between various design stages (Baumgartner & Reiser, 1998; Puntambekar & Kolodner, 2005).

Hmelo et al. (2000) designed a study to support sixth graders' understanding of the complex human respiratory system by constructing a working model of an artificial lung. Hmelo et al. (2000) recommended a few strategies to enhance students' knowledge and systematic thinking in designing artefacts. These strategies include introducing scientific terminology explicitly to develop early causal mechanisms; conducting reflective discussions and whole-class discussions seamlessly to promote idea-sharing and self-reflection; planning and structuring activities based on a time constraint and available resources; providing timely feedback; and connecting new tasks to students' prior knowledge (Hmelo et al., 2000). Puente et al. (2013a) elaborated that facilitators encouraged students to formulate arguments and explore alternative solutions for a design problem by asking reflective questions.

Puntambekar and Kolodner (2005) argued that planning whole-class discussions and small group discussions at appropriate intervals for idea articulation are necessary to unpack students' design ideas. They also suggested other strategies to facilitate student learning during DBL, such as chunking complex tasks into more manageable pieces, providing suggestions to help students focus on important knowledge and eliciting information to make connections between different design stages more explicit. Students also need help from facilitators to conduct good experiments for testing prototypes and justify results for emergent learning problems (Baumgartner & Reiser, 1998). Besides, facilitators problematised students' designs to help them revise their conceptual understanding of a subject area (Morgan, Moon & Barroso, 2013; Puente et al., 2013a). Problematising student work can further develop students' ability to solve a problem (Reiser, 2004). Through this strategy, students focus their attention on an aspect that needs a solution and learns to elicit their ideas (Reiser, 2004).

3. METHODOLOGY

3.1 Participant

The first author of this study played the role of the facilitator in the DBL context. The first author has 10 years of experience in teaching secondary school science in Malaysia and Brunei Darussalam.

3.2 Research Context

In this study, the facilitator implemented a DBL task with a class of Form 1 students from a Malaysian national school located in the suburban area in Johor state. There were 27 students of different ethnicities in this class. Among these students, 14 were male. The students were randomly divided into a group of three students, forming nine student groups (Group A to Group I). This is the minimum number required for a small group discussion (University of Minnesota, 2021). It is also a good number for a small team to prototype a new idea (Corrigan, 2021).

This DBL cycle was divided into 16 one-hour lessons. A real-life design task drove the DBL challenge (English & King, 2015). The DBL lessons focused on designing and constructing a water filter that could provide clean water to villagers inhabiting remote areas based on the design criteria (i.e., filter 100ml water in two minutes, produce clear water, economic). The students were required to use knowledge from STEAM (Science, Technology, Engineering, Arts and Mathematics) subjects to solve this design task in groups.

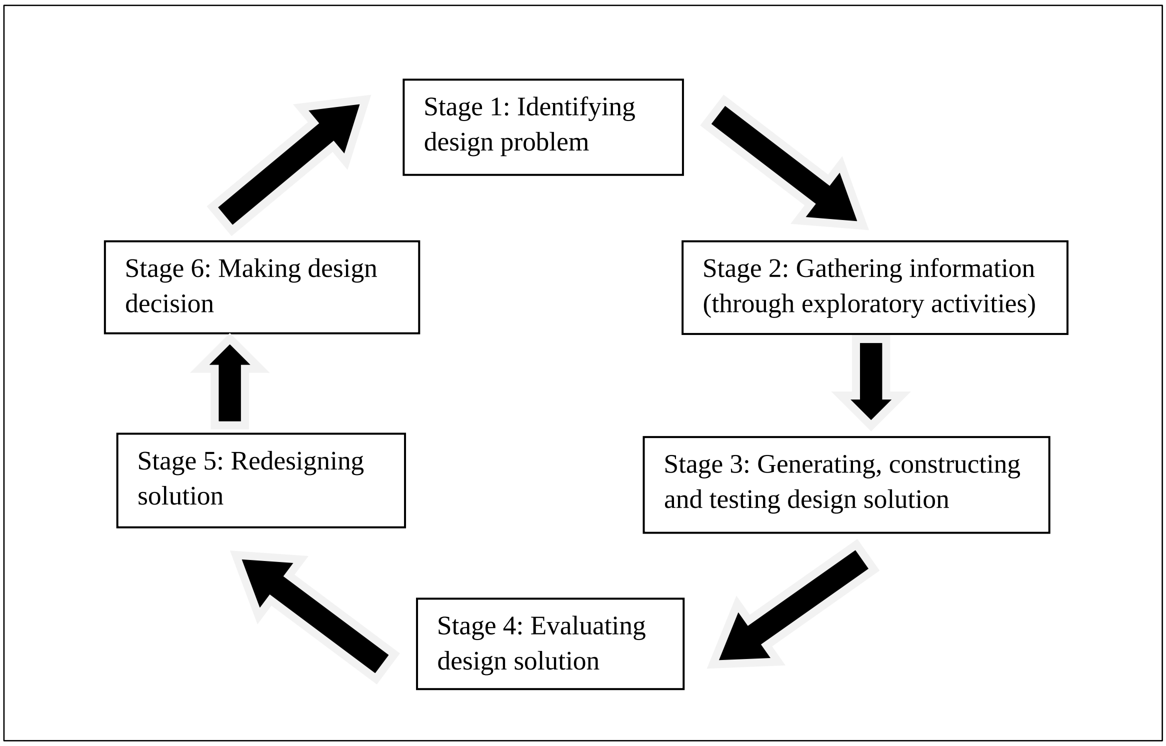

Figure 1. The Design-based Learning Cycle. Adapted from Hynes et al. (2011) and Puntambekar and Kolodner (2005)

The pedagogical framework of DBL was modified from the previous studies (Hynes et al., 2011; Puntambekar & Kolodner, 2005). As shown in Figure 1, the DBL cycle was divided into six major design stages: identifying design problem, gathering information, generating, constructing, and testing design solution, evaluating design solution, redesigning solution, and making a design decision. The problem identification stage gave the students time to analyse and define the learning issues and design problems using their prior knowledge. The information-gathering stage was for the groups to explore the nature of different types of filtering and discuss the experimental results before designing a prototype. At the stage of solution generation, the students were required to complete four tasks: selecting and justifying filtering materials, deciding the arrangement materials, identifying the concepts involved in the