Faculty of Cognitive Sciences and Human Development

# SCAFFOLDING IN LEARNING OF SCIENCE AND ITS IMPACT ON ACHIEVEMENT AMONG RURAL STUDENTS IN BAU

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# SCAFFOLDING IN LEARNING OF SCIENCE AND ITS IMPACT ON ACHIEVEMENT AMONG RURAL STUDENTS IN BAU

**IRIS TIA ANAK MEKUNG**

A project submitted
in partial fulfillment of the requirements for the degree of
Master of Science (Learning Sciences)

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The project entitled **Scaffolding in Learning of Science and its Impact on Achievement Among Rural Students in Bau** was prepared by Iris Tia anak Mekung and submitted to the Faculty of Cognitive Sciences and Human Development in partial fulfillment of the requirements for the degree of Master of Science (Learning Sciences).

It is hereby confirmed that the student has done all the necessary amendments for examination and acceptance.

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(DR. PHILIP NULI ANDING)

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| STEM | Science. Technology, Engineering and Mathematics |
| ZPD | Zone of Proximal Development |
| UPSR | Ujian Penilaian Sekolah Rendah |
| TIMMS | Trends International Mathematics and Science |
| WISE | Web-based Inquiry Science Environment |
| PBL | Problem-based Learning |
| SPSS | Statistical Package for the Social Science |
| *M* | Mean |
| LCD | Liquid-crystal Display |

# ABSTRACT

Teachers need to provide appropriate support to their students as they are struggling to understand the learning content. This study investigated scaffolding in learning of science and its impact on achievement among rural pupils in a primary school located at Bau, Sarawak. It also investigated the effects of gender on pupils' achievement using scaffolding and conventional teaching method. This study adopted an experimental research design. A total of 60 pupils, comprised of 30 males and 30 females took part in this study. The sample was divided into two groups, control and experimental with equal numbers of males and females. The control group was taught using the conventional teaching method, while the experimental group was taught using a scaffolding teaching method. Two research questions and three hypotheses tested at 0.05 level of significance guided the study. The instrument for data collection was constructed on the topic of Energy in primary Year 5 science curriculum. The reliability of the instrument was accessed using a test-retest reliability method, analyzed using the Pearson correlation coefficient and was found to be 0.947. Mean was used to answer the research questions, while two-way ANOVA was used to test the hypotheses. Results showed that pupils taught using scaffolding teaching method performed significantly better than their counterparts who were taught using conventional teaching method. However, there was no statistically significant difference between the mean scores of male and female pupils when taught using both teaching methods. Thus, educators are recommended to shift from conventional teaching to the method that relies on support and assistance to improve students' achievement in science.

Keywords: Science, scaffolding, achievement, gender

# *ABSTRAK*

## *SCAFFOLDING DALAM PEMBELAJARAN SAINS DAN KESANNYA TERHADAP PENCAPAIAN MURID LUAR BANDAR DI BAU*

*Guru perlu memberi sokongan yang sewajarnya kepada murid semasa mereka berusaha untuk memahami kandungan pembelajaran. Kajian ini dijalankan untuk mengkaji scaffolding dalam pembelajaran sains dan kesannya terhadap pencapaian murid luar bandar di sebuah sekolah rendah yang terletak di Bau, Sarawak. Ia juga menyiasat kesan jantina pada pencapaian murid menggunakan kaedah pengajaran scaffolding dan konvensional. Kajian ini menggunakan kaedah penyelidikan eksperimen. Seramai 60 orang murid yang terdiri daripada 30 orang lelaki dan 30 orang perempuan mengambil bahagian dalam kajian ini. Sampel dibahagikan kepada dua kumpulan, kawalan dan eksperimen dengan jumlah murid lelaki dan perempuan yang setara. Kumpulan kawalan diajar dengan menggunakan kaedah pengajaran konvensional manakala kumpulan eksperimen diajar menggunakan kaedah pengajaran scaffolding. Kajian ini dibimbing dengan dua soalan penyelidikan dan tiga hipotesis yang diuji pada tahap signifikasi 0.05. Instrumen bagi tujuan pengumpulan data dibina dari tajuk Tenaga dalam kurikulum sains Tahun 5. Kebolehpercayaan instrumen telah diakses mengunakan kaedah 'test-retest' yang dianalisis dengan menggunakan pekali korelasi Pearson dengan keputusan 0.947. Min digunakan untuk menjawab soalan-soalan penyelidikan, manakala ANOVA dua hala digunakan untuk menguji hipotesis. Keputusan menunjukkan bahawa murid-murid yang diajar menggunakan kaedah pengajaran scaffolding menujukkan pencapaian yang lebih baik berbanding rakan-rakan mereka yang diajar menggunakan kaedah pengajaran konvensional. Walau bagaimanapun, statistik menujukkan tidak ada perbezaan yang signifikan antara skor murid lelaki dan perempuan apabila diajar menggunakan kedua-dua kaedah. Oleh itu, para pendidik disarankan untuk beralih dari pengajaran konvensional kepada kaedah yang menitik beratkan sokongan dan bantuan untuk meningkatkan pencapaian pelajar dalam sains.*

*Kata kunci: Sains, scaffolding, pencapaian, jantina*

## 1. INTRODUCTION

Malaysia emphasizes on the significance of STEM education in order to meet the challenges of becoming a developed nation and stay competitive in STEM-driven economy. STEM initiative mainly aims to provide students with adequate skills to overcome the science and technology challenges and to guarantee that Malaysia has an adequate number of qualified STEM graduates (Malaysia Education Blueprint, 2013) that further achieved the targeted number of STEM workforce. Teachers play a significant role in delivering effective science knowledge, processes and practice, which further equipped students' various opportunities to apply these processes across many experiences. STEM skills obtained through class activities are the competence to explore, solve problems, designing and producing products (Hafizan, Shahali, Ismail, & Halim, 2016). Teachers and students are required to be creative to encourage higher order thinking skills by using the data they generated from the investigation of how and why phenomena are happening.

Studies have shown that young children are more open to learning and enriched by the experience they gained which will shape their typical cognitive development (Rao, Sun, Wong, Weekes, Shaeffer, & Lee, 2014). Since young children have cognitive capacities that are far beyond, thus promoting science inquiry and learning in the classroom is crucial. The children are required to be active learners and engaged in their learning activities to construct knowledge. Cognitive development happens in the context of the child's interactions with others such as peers, teachers, communities and with the surrounding. Meanwhile, learning is the result of the child's assisted construction of knowledge instead of transmission and absorption from the teachers. Traditional science teaching relied mostly on teachers, textbooks, and teacher-led demonstrations. Various alternative approaches have been encouraged in the teaching of science classroom including inquiry-discovery approach, contextual learning, mastery learning and so on. Students should not be taught directly but should allow them to discover things by themselves through hands-on activities, experimenting and problem-solving.

However, teachers need to give essential support to the students as they are struggling to understand the learning content. This support is known as scaffolding, as defined by Wood, Bruner, & Ross (1976), where learners complete the tasks that are within their range of competence while the components of tasks that are beyond of the learner's capability are controlled by an adult. Certain topics such as energy, motion, electricity, atomic, molecular structure and others are abstract in nature that include concepts and calculations brings frustration to students if insufficient support were given because they are difficult to learn. Therefore, providing scaffolding for difficult topics are crucial. Their learning process must be guided by a more capable peer or adult to allow them to move through the Zone of Proximal Development (ZPD), (Vygotsky, 1978). As the learner's abilities to understand the content increased, the scaffolding provided will be withdrawn. By using the scaffolding strategy, the learners will be able to accomplish more complex learning tasks and engage more advance in thinking and problem solving (Bransford, Brown & Cocking, 2000).

### 1.1 Scaffolding

The term scaffolding was originally used by Bruner (1975) to describe the engagement between a parent with a child or between an instructor with a student, where support given was just enough based on the child ongoing progress. Subsequently, Wood et al. (1976) explained scaffolding as support given by an adult in completing the components of tasks that are beyond the learner's capability and focused only on the components that are within the child competency. Vygotsky (1978) argued that learning happened initially at the social or interindividual level, thus social interactions play a vital role in cognitive development. In his work, Vygotsky introduced the term zone of proximal development (ZPD) which is defined as "distance between the child's actual developmental level as determined by independent problem solving and the higher level of potential development as determined through problem solving under adult guidance and in collaboration with more capable peers" (Vygotsky, 1978, p. 86). Meanwhile, scaffolding in classroom context is described as the temporary assistance provided by teachers to assist their students in completing a task or develop an understanding on new knowledge in order to complete identical tasks independently in the future. Apart from that, scaffolding is viewed as a key component of cognitive apprenticeship, where learners become problem solvers with appropriate assistance from teachers who scaffold students through teaching, tasks and hints, without giving the essential answers (Quintana et al., 2004).

In spite of numerous interpretations and definitions of scaffolding, Van de Pol, Volman & Beishuizen (2010) have recognized three characteristics of scaffolding which include contingency, fading, and the transfer of responsibility.

**Contingency**. Scaffolding given by teachers is relying on the students' capability and present level of their performance. Puntambekar (2009) opined that contingency is one of the most crucial characteristics of scaffolding since adult or teacher usually performs a continuous assessment on the learner's ongoing progress and offers suitable assistance in the certain tasks that are beyond their ability. Wood (2003) categorized contingency into three types: (i) Instructional contingency which describe the ways to support the learning activities; (ii) Domain contingency which cover the things teacher needs to focus on the next step or next lesson; and (iii) Temporal contingency which relates to the matter of if and when is the perfect time to intervene the support or learning tasks. There are several ways on how to apply contingency support to students in the classroom. One effective way to provide contingent support to the learners is through utilizing ongoing diagnostic approaches. Thus, teachers must fully master the tasks and understand the learners' abilities, together with their learning progress (Puntambekar & Huscher, 2002). After determining the students' current capability, the teacher will continuously monitor each of their learning progress at certain points of time. The continuous monitoring will help the teacher to plan suitable tasks or activities for his or her students for the next lesson. Another way is by applying intervention to the current tasks based on the ability of the student, an advanced student may need more challenging task compared to a weak student, which more simple task is suitable to enable the student to complete the task independently.

**Fading**. The scaffolding is fading at certain points where the learner will able to attain mastery of the new knowledge or task, solve a problem or achieve the desired goal independently. Fading is important for a successful scaffolding because it enables students to complete the task and prepare them for the similar or advanced task independently in the future. This process is known as Internalization by Vygotsky (1978), which stated that the scaffolding support can be removed whenever the student has internalized the support. However, the level of fading needed is relying on the student's present level of development and capability to complete the task (Van de Pol et al., 2010). This characteristic is closely associated with the third characteristic of scaffolding which is the transfer of responsibility.

**Transfer of responsibility**. The learner internalizes the new knowledge or skill in order for a change in cognition or effects to occur. As the scaffolding fades over time, learners will gradually improve in their competency until they are able to master their own learning independently. The responsibility of completing a task is transferred slowly from teacher to learner (Van de Pol et al., 2010). A perfect scaffolding will benefit the learners as they internalize the assistance given (Rogoff, 1990). Transfer of responsibility is also directly associated with the learner's mastery on the subject matter and perceptions of self-efficacy.

### *Forms of Scaffolding*

There are three known forms of scaffolding mainly one-to-one, peer, and computer or paper-based scaffolding.

**One-to-one scaffolding**. Described as the relation of one teacher with one student to continuously assess the present level of the student, allocate the relevant amount of guidance for the student to achieve and acquire skill at the given task, and adjust the guidance as needed until the scaffolding can be fully withdrawn and the student can take responsibility (Belland, 2014; Chi, 1996; Graesser, Bowers, Hacker & Person, 1997; Lepper, Drake and O'Donnell-Johnson, 1997; Van De Pol et al., 2010). This form of scaffolding is believed to be a perfect form of scaffolding that fit the needs of the learner through instructional, domain and temporal contingency. In reciprocal teaching, teachers model the process of summarizing, questioning, explaining and clarifying in reading text passages that guide the students to enhance their reading comprehension and remain stable for a longer period of time (Palincsar & Brown, 1984). By focusing on the four components of readings motivate students to actively involved in the learning process and access reading on a deeper level. Thus, it is a great strategy for students to be responsible for their own learning and thinking. However, one-to-one scaffolding is often not practical when involving a large classroom which consists of 20-30 students.

**Peer scaffolding**. Involves the support obtained from more capable and knowledgeable peers. Rogoff (1990) declares that peers can be considered as valuable scaffolding agents in terms of providing motivation and encouragement, which are vital elements in a learning context since peers commonly encourage each other to think and contribute ideas. This type of scaffolding can help in a large classroom and is a cost-effective way to scaffold the whole classroom. Students that have different capabilities can assist their peers to enhance their higher-order thinking. Even though peer scaffolding could be beneficial, but sometimes in a certain condition, it also could be undesirable (Rogoff, 1990). For example, when there is a broad gap between their partner's and learner's capability, the partner may not be able to assist the learner to reach their potential if too much or not enough assistance is provided. Similarly, if the students in the classroom are of the same abilities, effective peer scaffolding cannot be provided. In order to nurture effective peer scaffolding, students need to be given an opportunity to engage in peer tutoring and also a framework to assist their delivery of scaffolding. Students should be encouraged to critically access or assist their peers rather than expecting them to automatically engage in peer tutoring without providing the opportunity to do so. As an example, in the *Learning by Design* model (Kolodner et al., 2003), students articulate design ideas in a poster session and require to debate each other's ideas. In this design, it is reported that students performed well on collaboration and also metacognitive skills. Moreover, *Learning by Design* technique also helps average-achieving students to perform better compared to high-achieving students who learned through the traditional method. Apart from that, peer scaffolding needs a clear framework to guide the scaffolding with the correct strategies and to use them when needed (Belland, 2014). Students need to be taught the technique to ask critical thinking questions and frameworks to evaluate their own work as well as others.

**Computer or paper-based scaffolding**. Involve a computer or paper-based tools that can assist students to engage and obtain skill at tasks that are far beyond their capabilities (Belland, 2014). By using a computer-based tool, students can be guided to solve complex and ill-structured problems. This form of scaffolding is often used in self-contained learning environments, online discussion and as addition to classroom-based instruction. Self-contained environments are made up of an enabling context, resources, scaffolds and tools (Hannafin, Land & Oliver, 1999). As an example, Web-based Inquiry Science Environment (WISE) used by Linn, Clark & Slotta (2003) enable students to explore the problems that are related to the tasks then, scaffolds are provided to assist students to articulate their critical thinking on the possible solutions to the problems. The WISE provide scaffolds that focus on the epistemology of science, and the students need to observe their progress and create predict the results (Lin et al., 1999). Meanwhile, online discussion that integrates computer-based scaffolds also able to promote critical thinking among students. For example, Choi, Land and Turgeon (2005) develop an online argumentation which showed that the scaffolds provide in the system have significantly promoted more problem-solving action and increase the generation of coherent arguments.

### *Techniques of Scaffolding*

It is teachers' responsibility to guide students to become independent learners, even sometimes motivated students are unwilling to be responsible for their own learning. However most teachers usually only give instruction, step back and monitor what their students do, rather than provide scaffolds that guide, continuously assesses the suitability of the instruction over time and gradually remove the responsibility to the students. This technique is known as guided instruction where the teacher provides scaffolding with prompts, cues, and questions through modelling for the students, followed by working together until they are able to become more independent. Later, integrate a collaborative learning feature during the lesson where students are provided with the opportunity to discuss and negotiate among themselves about the task. Finally, the learners will work independently by applying the knowledge that has been learned through the lessons, guided exercise and collaborative work to create new and authentic outcomes. Fisher and Frey (2010) describe the utilization of these scaffolds constitutes the combination of the art and the science of teaching.

Scaffold need to be done when a learner does not show any progress on some stage of a task or unable to understand a certain concept. Literature has revealed various techniques of scaffolding. Ellis and Larkin (1998), as cited in Larkin (2002) outline the steps where scaffolds can be done successfully in a classroom:

**First, the teacher does it.** The teacher shows or models the way to do a new or difficult task. For example, the teacher demonstrates a process to represent the content that they are expected to perform independently to build their understanding of the content.

**Second, the class does it**. The teacher and students work together to complete the task. During this stage, the teacher assists the students through prompts and cues to ensure that they are in the correct track.

**Third, the group does it**. Students collaborate with their partner or in a small group to perform the task. At this point, students are given the opportunity to give ideas and support each other to achieve the goal.

**Fourth, the individual does it.** This is the point where students work independently without external support. Now, the learning responsibility has been transferred completely to the learner. In the future, the learners will able to perform the same task or skill by themselves.

On the other hand, Silver (2011) reported four general steps to scaffold instruction in a classroom: (1) assess learner's prior knowledge and experience, (2) connect the learning content with students' understanding and capability, (3) chunk the task in a manageable form and provide feedback, and (4) integrate verbal cues and prompts to guide students.

Another techniques developed by Fisher and Frey (2010) for effective scaffolding also involve four steps which are: (1) questioning to assess students understanding, (2) prompting to promote students' cognitive and metacognitive processes, (3) cueing to enable students to pay attention on particular information, error or partial understandings, and (4) explaining and modelling whenever is needed in completing the task.

Despite the diverse techniques to implement scaffolding in learning, the most crucial part is to apply appropriately and continuously depending on the environment, age and capability of the learner and the content or skill to be introduced. These elements are important to make sure the success of the scaffolding.

### *Implementation of Scaffolding*

In present educational practice and research, the interpretation of scaffolding is exceedingly diverse resulting to inconsistent implementation and operationalization of scaffolding metaphor and it "is sometimes used loosely to refer to rather different things" as mentioned by Hammond (2002, p.2). With the growth of project-based and design-based environments for teaching science and mathematics in a classroom context, scaffolding is widely used in describing the prompts and hints given in tools to assist learning (Putambekar & Hubscer, 2005). Hence, scaffolding does not only refer to the interactions between individuals but also involves resources, artifacts and environments themselves which are used as tools to scaffolds. Tools and resources, as well as curriculum and artifacts are needed to assist student learning in the classroom. Linn (1998) suggested that tools and resources are used for showing appropriate features of the activities or approaches and making furtive processes observable that further encourage peer interactions.

According to Wood et al. (1976), there are six types of guidance that an adult can offer: (1) enlisting the child's interest, (2) decreasing the levels of independence by simplifying the task, (3) sustaining direction, (4) stressing the essential task features, (5) managing frustration, and (6) showing the best ways of solution. However, different learners may have different stages of assistance needed over a period of time-based on their learning or cognitive ability. At these different stages of learning progress, different scaffolding methods or strategies are needed. The adult may apply several strategies such as model the best solutions (Wood et al., 1976) or the suitable techniques (Palincsar & Brown, 1984) or supply assorted types of assistance such as providing explanations, promote participation, modelling ideal behavior and supply clarifications (Roehler & Cantlon, 1997). Appropriate sequencing of activities and ideal assistance are crucial in order to challenge as well as to expand students' capabilities. Through participation in such tasks, students are forced to learn beyond their present capabilities and degree of understanding, where learning and internalization of new understanding occur (Burns & de Silva Joyce, 2005). Thus, scaffolding is not only supported by a teacher but through the designed activities to guide learners to work with increasing independence, apply higher order thinking and problem solving so that the new skills or knowledge can be used in different contexts in the future. Effective scaffolding needs clearly articulated aims in line with structures learning activities in order to allow learners to expand their current understanding. The aims for any specific task require to be placed within the wider framework of a planned activity.

## 1.2 Teaching and Learning of Science

### *Subject Matter Content Knowledge*

Subject knowledge is related to content, process and personal knowledge. Wineburg and Wilson (1991) propose that the representation of a subject matter domain in a classroom context is related to the content knowledge own by the teacher and the way the teacher understand his or her students learning abilities. Deep and rigid subject matter content knowledge is very important in a constructivist classroom which requires an understanding of the structure of discipline and also its epistemological framework. The knowledge guides teachers to design learning tasks that assist students in understanding concepts and hypotheses, in assisting a discussion to develop a shared understanding, offer support on sources for supplementary formal knowledge and correct misconception at the same time.

In science, content knowledge or propositional knowledge is defined as the knowledge of facts, theories and ideas, and understanding of the arranged principles and main contexts of the discipline (Baker, 1994). For example, a study of the human body may involve knowledge of human control systems, their response to stimuli and homeostasis and other forms and functions associated with the human body. This scientific phenomenon is ubiquitous in students' daily life. Even though, students faced with science-related matters in both formal and informal situations, yet systematic and sustained participation with scientific inquiries develop through their educational experiences in school. Classroom instructional quality is vital in expanding students' experiences and prerequisites their learning in an individual's background since it offers