In-service teachers’ scaffolding in teaching and learning mathematics

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Abstract. The information about teachers' scaffolding in teaching and learning mathematics, especially in Indonesia, is still limited. This study aims to investigate mathematics teachers' scaffolding in a teacher certification programme (Pendidikan Profesi Guru hereafter PPG) in Banda Aceh. This study involved two in-service teachers participating a professional experience placement program in one of Junior High Schools in Banda Aceh. The video recordings of participants' teaching practices were analysed qualitatively to examine the balance of teachers' scaffolding and students' responses based on five scaffolding strategies. The results show that both teachers used the pseudo-contingent type of scaffolding, in which the teachers were still not able to appropriately facilitate students to learn the given topic. T1 conducted four scaffolding strategies, namely: offering explanation, inviting student participation, verifying and clarifying student understanding, and inviting students to contribute clues. T2 provided five scaffolding strategies, namely: offering explanation, inviting student participation, verifying and clarifying student understanding, modelling the desired behaviour and inviting students to contribute clues. Therefore, the PPG likely needs to implement a specific strategy to improve teachers' ability to provide effective scaffolding for students' learning, for example, by providing extra time for in-service teachers to practice implementing the appropriate scaffolding during peer-teaching activities.

1. Introduction
The learning process at school usually involves the process of understanding the information delivered by teachers, which aims to develop students' cognitive knowledge as well as to help students to solve problems or achieve learning goals [1]. In the learning process, students need to construct their knowledge by connecting pieces of learning information [2]. A teacher is required to be able to play his/her role properly in managing learning by becoming a facilitator and motivator for students [3]. To be an effective learning manager, a teacher needs to have particular strategies in facilitating students to build their cognitive knowledge. The strategies are well known as scaffolding.

Teaching mathematics is usually intended to help students to understand the topics through problem solving. Mathematics is a crucial lesson to be taught at schools since it consists of the knowledge of logical sequence patterns [4]. The teacher, as an educator or instructor, is one of the determinants aspects to the success of educational goals [5]. Teaching instructions play a crucial role in students' learning. However, the teaching instructions will not work without a teacher's role to
support students' learning. The presence of the teacher is still needed in order to help students to achieve their learning goals. Triangle and rhombus are the topics taught in Year 8 junior high school. In general, students have difficulty in understanding the topics, such as identifying the area of two-dimensional shapes. Therefore, teachers need to facilitate students to develop their mindset in learning the topics, which aims to avoid any misconception during the construction of mathematical concepts [6]. One of the teacher's potential efforts to prevent students from having misconception is by providing appropriate scaffolding through the teacher-student interactions [7,8].

Scaffolding is a temporary support used by teachers to facilitate students in building their understanding of a particular concept until the students are able to solve the problems related to the concept by themselves. Teacher as a learning facilitator should strive to provide students with effective learning experiences [9]. A teacher serves as a professional who is required to develop his/her teaching abilities and skills continuously. Without adequate teaching skills, a teacher will tend to find difficulties in carrying out and enforcing their responsibilities effectively [10]. Adequate teaching abilities and skills also could help a teacher to provide students with effective scaffolding [11]. Moreover, the ability of mathematics teachers to facilitate students in building research-based knowledge is still low [12].

Based on those facts, the Indonesian government organized the teacher certification programme (Pendidikan Profesi Guru hereafter PPG) in order to develop Indonesian teachers’ professionalism [13]. The program aims to train teachers to be professional teachers, i.e., teachers who are able to carry out their duties and obligations properly. This idea is indicated in the principles of professionalism where a teacher is considered as professional once the teacher can conduct the teaching effectively [14]. Therefore, a professional teacher is required to be capable of facilitating students to dig more in-depth information and expand their knowledge by relating the newly received information to their prior knowledge [15].

The PPG program is classified into the certification programme for pre-service and in-service teachers. The implementation of the PPG program could train and prepare the participating teachers with the abilities and competencies needed by professional teachers. According to the regulation of the Ministry of Research, Technology and Higher Education No. 55 Year 2017 concerning Teacher Education Standards, the evaluation of the success of in-service teachers’ teaching includes several factors: the process and product of teaching aids design, pre-service teaching process and outcomes, test competency, and living community. However, the material about scaffolding in the teaching process has never been delivered during the PPG program for in-service teachers before they start teaching in schools. Moreover, inadequate knowledge of the scaffolding strategies owned by the in-service teachers is also caused by the assessment indicators during the teacher certification programs that have not focused on scaffolding strategies for teaching mathematics.

Several studies have shown that the provision of scaffolding in mathematics learning has not been optimal. This poor provision can be seen as the teachers who still tended to ignore the diagnostic analysis of students’ learning difficulties, which resulted in a lack of learning supports received by students [3,16]. Teachers should continuously develop their teaching abilities and skills. Teacher professional education is intended to train teachers with the abilities to carry out their responsibilities as professional teachers, who have competence as professional educators. In fact, the education quality of Indonesian students still shows poor results, which were exhibited from the poor quality of the learning process and low student learning outcomes [17]. This fact has encouraged the researchers to examine in more detailed "What scaffolding strategies used by teachers who participated in the teacher certification programme?"

2. Method
This study used a qualitative approach. The subjects of this study were two in-service teachers with initials T1 and T2. The teachers were conducting the professional experience placement program at one of the junior high schools in Banda Aceh collaborated with PPG Syiah Kuala University in 2018.
2019. They are female teachers who teach mathematics in junior high schools in Aceh. This study focused on scaffolding strategies that occurred between teachers and students during the learning activities.

Data were obtained by recording the learning process using video recordings (Handycam). Inservice teachers’ scaffolding ability was observed during the teaching process conducted by the teachers without informing them about the purpose of the recording so that they did not focus on scaffolding ability. The researchers then transcribed the video into a written form. This research classified the interactions between teachers and students into contingent, non-contingent, and pseudo contingent [15,18]. However, to evaluate the implementation of the contingent scaffolding, it needs an analysis of the scaffolding strategies used in mathematics teaching, including diagnostic, intervention, or checking [16,19]. Furthermore, this research will refer to five different scaffolding strategies that can be used by teachers to help students, namely 1) offering explanations, 2) inviting student participation, 3) verifying and clarifying student understanding, 4) modelling desired behaviour, and 5) inviting students to contribute instruction [20].

3. Results and discussion
This study investigates the scaffolding activities carried out by two in-service teachers, namely T1 and T2. T1 was observed during her teaching practice about rhombus. It appeared that T1 conducted some scaffolding during the apperception phase; that was when T1 reminded students about the topic of plane geometry that they had learned in elementary school. T1 then displayed two-dimensional shapes and asked students to name the shapes one by one. Almost all students were able to name each shape shown by T1 correctly. Although a few students were not able to mention each shape displayed by the teacher. This finding showed that students were able to recall the concepts of two-dimensional shapes. T1 also asked students to form groups of five by themselves, and then asked students to solve worksheets in their groups. T1 helped students to understand and taught them how to do the worksheet. While students worked on the worksheet, T1 assisted the groups who found difficulty in completing the worksheet. Students’ worksheet 1 made by T1 herself is shown in Figure 1.

2. Determine the area of the rhombus
Direction:
Figure a: The length of the first diagonal namely \(d_1\) and the second diagonal namely \(d_2\). Figure b: Cut the side of one of the diagonals into two equal triangles. For example \(d_1 = a + a\) and \(d_2 = b + b\). Figure c: Cut one of the sides of a into two equal new triangles. Figure d: Paste the triangle pieces into a rectangular shape like Figure d.

![Figure 1. Students' worksheet 1 made by T1 about the rhombus.](image)

The following section describes an interaction fragment that occurred when T1 provided scaffolding; T1 questions are classified into diagnostic question (D), intervention (I) and checking (C).
Fragment 1 (Offering explanation)

T1: (T1 wrote the rhombus area formula in the student notebook)
   “How much is the area?” [I]
S: "162."
T1: “This \(d\) is unknown, isn’t it? So, let's just say it is ... So ...” [I].
   (T1 wrote the students' worksheet answer on student's notebook)
S: “...”
(Students only paid attention to the answer written by T1)
T1: “How long is the diagonal? Nine?” [I]
   (At the same T1 pointed at the students’ worksheet. T1 then guided students to continue the
settlement algebraically)

Fragment 2 (Inviting student participation)

T1: “From the picture, we can find the area and perimeter of the rhombus, from the picture try to note” [I].
   (T1 left students without waiting for student responses)

Fragment 3 (Verifying and clarifying student understanding)

T1: “What is the diagonal? Just now, there are two diagonals” [D].
   (T1 guided students to open the textbook. T1 and students paid attention to the textbook).
S: “...”
T1: “There are two diagonals. So, diagonal one and diagonal ...?” [D]
S: “Two”
T1: “Haa... Multiplied” [I]
S: “So, diagonal two ...?”
T1: (T1 guided students to write the answers).
   “Multiplied in here. Multiplied, diagonal first multiplied by ...?” [C].
S: “...”
(Students write the answers to question T1 on the students' worksheet).

Fragment 4 (Modelling of desired behaviours)

T1 did not use the scaffolding strategy type of modelling of desired behaviours.

Fragment 5 (Inviting students to contribute clues)

T1: “If both of the diagonals are known, now, how do you identify the perimeter of the rhombus?
   Use?” [D]
S: “...”
T1: “There, it doesn't have the rhombus side on it, right? So, we must use which formula?” [D]
S: “...”
T1: “Pythago...?” [I]
S: “...ras”

Interactions in fragments 1 to 5 have shown contingent scaffolding interactions by providing
diagnostic questions, intervention and checking. However, T1 rarely checked students' understanding
that crucial to verify the extent of students' understanding. Meanwhile, the results of the video recorder
analysis showed that some errors made by T1 on the other fragments. For example, in fragment 5, T1
did not explain properly about the diagonal position of the rhombus after being transformed into a
rectangular shape. As a result, students became confused and less motivated to solve the problems on
the students' worksheet. Students' neglect could be seen from the video wherein students did not
seriously get involved in group discussions. In addition, T1 often left the students after giving
scaffolding without giving the chances for the student to respond or making sure whether or not the
students understood the instruction. As a result, when T1 returned to previous other scaffolding, the
students still found similar difficulties as the previous problem. In contrast, the teacher was supposed to give sufficient and clear scaffolding for the students to reduce confusion or uncertainty among students when answering the problems, which might not have hindered their initiative and motivation in learning [21].

Although the teacher eventually provided the groups with scaffolding, students still found difficulties with the same problems. Students should have been given scaffolding which could allow them to solve the problems [22]. Furthermore, in the beginning, T1 did not recall the Pythagoras formula, which was supposed to be the initial knowledge for the students to understand problem solving in the rhombus topic. However, in this case, the students were confused when T1 mentioned the term of Pythagoras (See fragment 5). This finding indicated that scaffolding could be successful if the teacher can recall students’ prior knowledge and abilities, which can be connected to the new knowledge as well as can improve students' learning motivation [23]. The results of this interaction imply that the application of scaffolding does not work well when students are not sufficiently supported to overcome the difficulties that they face. Therefore, it could be concluded that T1 is a pseudo contingent since T1 delivered a wrong understanding to students when she intervened in students' learning. In addition, T1 was also hesitant in conducting intervention strategies on fragment 1. T1 even showed the answer key of the students' worksheet and wrote the correct answers to the questions on the student's book to be later copied by the students on the students' worksheet.

The observed T2 addressed a broad material and perimeter of the triangle. T2 did some scaffolding during the apperception phase by showing questions through PowerPoint slides, which was "Given a right-angled triangle ΔABC, with the right angle is at point B, and the length of AB = 8 cm, BC = 6 cm. What is the area of ΔABC?" The interactions that occurred during the apperception phase were fruitful, which could be seen through interactive conversations between the teacher and the students while solving the problem together. T2 asked students to form groups of five and provided each group with students' worksheets. While students worked on the worksheet, T1 assisted the groups who found difficulty in completing the worksheet. The following are interaction fragments that occurred when T2 provided scaffolding.

Fragment 6 (Offering explanation)

T2 : “This is understanding the concept first. Here, here, here. You say these eight already, if this sign like this, the same. This?” [D].

(A at the same time T2 pointed the problem on students' worksheet)

S : “Fair division...”

T2 : “So?” [D]

S : “...”

T2 : “The solution?” [I]

S : “The solution? Identify this one first ...”

(A at the same time T2 pointed the picture on students’ worksheet)

T2 : “This first son gets eight meters, already divided, so this sign, this has already been presented because I explained earlier. To explain questions like this. Illustrated in the pict...?” [I]

S : “Picture”

Fragment 7 (Inviting student participation)

T2 : “You said that already, this base of the triangle is eight meters. Ok. So this, a total of all this (216 m²), firstly got ...?” [D].

(As in Figure 2)

S : “Eight”

T2 : “You have to imagine all of this area. In total, all of that, this, this. All of this is this total (216 m²)” [D]

(At the same time T2 pointed the problem on students' worksheet)

S : “...”
T2: “This first son can be eight meters. How much is this?” [D]
S: “Eight”
T2: “Eight too. This?” [I]
S: “Eight”

**Fragment 8 (Verifying and clarifying student understanding)**

T2: “Prove it!” [I]
S: “It’s already, miss.”
(At the same time T2 showed the results of her work on the students’ worksheet)
T2: (T2 checked students’ work)
“This is not the base of the triangle, this. This is all area, this. Area. This base is eight. This eight is not the base of the triangle, but area” [I].
(At the same time designated the students’ worksheet and made a circular pattern on the triangle image in question)
S: “This area, miss?”
T2: “Aaaaa... Area of the first triangle ...”
S: “So this base of the triangle?”
(Students looked confused).
T2: “This can not be here because the question is not the base of the triangle. The question is the total area instructed, right?” [I].
(At the same time T2 pointed on the students’ worksheet)

**Fragment 9 (Modelling of desired behaviours)**

T2: “This is already C ...” [I]
S: “Hmm...”
T2: “So, if A plus B. This.. Where is A?” [D]
S: “...” (Refer to the picture in students’ worksheet).
T2: “This A. A plus B, is it bigger or smaller than C? Try to change it, is it the same? Or is it equal or even more than C?” [I].
(T2 left the students)

**Fragment 10 (Inviting students to contribute clues)**

T2: “Get there, do you think Mr. Amir does a fair share of the inheritance? Explain your reason”.
(T2 read out the questions to the students’ worksheet)
“If you were told that, so it was...?” [I]
S: “Eight”
T2: “This eight. This is eight, too. What is total is this (216 m²)” [C]
S: “............”

The interactions that occurred in fragments 6 to 10 by T2 have indicated a contingent scaffolding interaction, including providing diagnostic questions, intervention and checking. However, T2 rarely checked students' understanding which is crucial to verify the extent of student understanding. In fact, one of the importance of scaffolding is to monitor and examine students' understanding. The results of the video recorder analysis showed that T2 made some errors on the other fragments. For example, in fragment 8, T2 used a strategy of verifying and clarifying student understanding. However, the strategy used was incorrect because it seemed that T2 had a poor understanding of the basic concept of a triangle, by saying that the base of a triangle is its area. As a result, students become confused and less motivated to solve problems on students’ worksheets. Although the teacher finally provided the scaffolding to the groups, students still found similar difficulties with the same problem. The results of this interaction imply that the application of scaffolding does not work well when students are not sufficiently supported to overcome the difficulties that they face. Students are very dependent on the assistance provided by the teacher. Therefore, it can be concluded that T2 is a
pseudo contingent since the teacher told students the wrong concept when she intervened in students’ learning. T2 even showed small folded paper containing the answer keys of the worksheet to the students. A sample problem of the worksheet made by T2 is shown in Figure 2.

DIVISIONS OF RICE FIELD

Look at this picture.

Mr. Amir will give his land on the hillside, as shown in the picture, for his three children. The land area is 216 m².

In your opinion, is Mr. Amir fair in dividing his land for his three children? Explain your reason!

Figure 2. Students’ worksheet about perimeter and area of a triangle made by T2

Based on the results of the video recording analysis, it is shown that T1 and T2 have provided five scaffolding strategies [22]. However, the frequencies of scaffolding strategies used by T1 and T2 vary, as shown in Table 1.

| Teachers | Frequencies of Scaffolding Strategies |
|----------|---------------------------------------|
|          | 1         | 2         | 3     | 4     | 5     |
| T1       | 13        | 2         | 6     | 0     | 5     |
| T2       | 6         | 9         | 6     | 1     | 7     |

Based on Table 1, T1 does not use a scaffolding strategy 4 (modelling of desired behaviour), while T2 uses all scaffolding strategies. T2 tended to implement the scaffolding strategy of inviting student participation more often, while T1 mostly preferred to use the scaffolding strategy of offering explanation.

Furthermore, T1 rarely used the scaffolding strategy of inviting student participation and modelling of the desired behaviour. Meanwhile, T2 hardly implemented the strategy of scaffolding modelling of the desired behaviour. Nevertheless, the main reasons behind the choosing of each scaffolding strategy by both teachers are still unclear, since no further in-depth interviews were conducted with both teachers. In fact, the strategy of inviting student participation and modelling of the desired behaviour requires adequate basic knowledge of the subject areas as well as the decision-making strategies on what needs to be done in certain circumstances.

4. Conclusion
T1 carried out four scaffolding strategies, including offering explanations, inviting student participation, verifying and clarifying student understanding, and inviting students to contribute instructions. T2 provided five scaffolding strategies, namely: offering explanations, inviting student participation, verifying and clarifying student understanding, modelling desirable behaviour and inviting students to contribute instructions. However, the scaffolding strategy implemented by both in-service teachers in this study is categorized in pseudo contingent type because both of them were still
not able to properly facilitate students with the materials. Therefore, the PPG program should consider implementing specific strategies to improve the ability of teachers to provide students with effective scaffolding. One strategy that could be done is by providing additional time for the teachers to practice on how to design the appropriate scaffolding during peer-teaching activities.

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