On the Design of a Scaffolding-Based Online Digital Media for facilitating Self-Regulated Learning

**Abstract.** As the COVID-19 limits the face-to-face classroom activities, the importance of good Self-Regulated Learning (SRL) becomes more and more increasing. One way to help facilitate the students’ SRL is through the use of online digital media. In this research, we were designing scaffolding-based online digital media and implementing it to 30 junior high school students. This research is development research following the ADDIE (Analyze, Design, Development, Implementation, Evaluation) concept. To test the effectiveness of our media after the implementation stage, we compare the SRL score of students who did not use our media with students who use our media. Students in the experimental class show better SRL scores than their peers in the control class. We conclude this research by giving some essential characteristics that will be useful for the development of other scaffolding-based online digital media.

1. Introduction

Human self-control is essential because, without it, concepts such as responsibility and accountability would not make any sense [1]. Authors refer to this self-control as *self-regulation* to emphasize the flexibility and adaptability of human self-control [2]. People with poor self-regulation often show impulsive and unregulated behavior, and it might cost them and their surroundings.

 One of the domains of self-regulation is Self-Regulated Learning (from now on abbreviated as SRL). SRL is aligned most closely with educational goals [3]. Most of the time, students who actively engaged in self-regulated learning can be identified easily in a class. Their approach to the learning process is very different from their passive classmates. They participated in educational activities with confidence, diligence, and resourcefulness. Self-regulated learners are aware of their capability and limitations. Because they know what they can and what they cannot do, unlike their passive classmates, they proactively seek out information when needed and take the necessary steps to master it. Even when their learning environment is inadequate—for example, facing confusing teachers and abstruse textbooks—they still find a way to succeed [4]. They are assumed to know how the learning environment can affect them covertly and behaviorally during acquisition. Because of that reason, they will try to improve that environment through the use of various strategies [5]. Regarding the acquisition of knowledge, self-regulated learners view it as a systematic and controllable process, and they know the strategies to do it. They also accept greater responsibility for their achievement outcomes [6].

 Good SRL becomes increasingly essential nowadays as the students can not attend the classroom because of COVID-19. Following the instruction from the Ministry of Education and Culture, classroom activities in Indonesia are implemented online to avoid escalating the pandemic further [7]. Attending the classroom from home is very different from visiting the classroom physically. By doing the class activity online, they need to manage themselves with greater responsibility than ever.

 Because of the importance of SRL, it is crucial to help students to facilitate their SRL. One way to facilitate students’ SRL is by using online digital media. But not all online media can help the students. Hence, there’s a need to design a media that can help to facilitate students’ SRL without the assistance of the teacher.

1. Theoretical Background
	1. Self-Regulated Learning

SRL can be described as thoughts, feelings, and actions that arise on their initiative, which are systematically guided by personal goals [8]. Students who are actively involved in SRL can control their cognition, behavioral, and motivational dimensions [9–13]. In practice, SRL involves four phases, namely (1) planning, (2) monitoring, (3) control, and (4) reflection [8,14]. Each of these phases is applied to the cognition, motivation, and behavior of self-regulated learners. For example, reflection is not only done on the cognitive dimension (for example, reflecting on the results of the test). Reflection also presents on the motivational dimension (for example, reflecting whether they have enough motivation or not when learning) and behavioral dimension (for example, reflecting whether the effort put into learning is enough).

 This research was conducted on the basis that SRL could be trained [15,16] and measured. To measure someone’s SRL level, one of the most frequently used ways is to use a questionnaire [17]. In this research, we use a questionnaire consists of 23 statements. We use the Likert scale with five levels; the students choose whether they strongly agree, agree, in doubt, disagree, or strongly disagree with a statement. Based on whether a statement is a negative statement or a positive statement, we assign the number 1-5 for each choice. After that, we sum each student score to know how good is their SRL.

* 1. Scaffolding

The term scaffolding is defined as a process that allows a child or beginner to solve a problem, carry out a task, or achieve a goal that is actually beyond his ability if it is done without assistance [18]. In addition to the process, scaffolding can also be in the form of tools in a learning process, assignments and instructions, guiding questions, all of which aim to guide students in the learning process [19,20]. By using scaffolding, students are led to solving easier problems so that in the end, they can solve more complex problems [21].

 In this study, the type of scaffolding used is *fixed scaffolds*. Fixed scaffolds are designed to help students by providing questions related to the material being studied to encourage qualitative and quantitative changes (for the better) in their understanding of the material [22,23]. Based on its design, one example of fixed scaffolds is guiding questions, which we use in this study. We broke down a question into easier questions that actually are the step-by-step to solve the complex problems. By solving those easier questions, they were doing the steps required to solve a complex question or deepening their understanding of that complex question.

 Scaffolding must only be a temporary help [24–26]. Each form of assistance provided must be slowly reduced out so that students do not depend on the support [25]. It means that the guiding questions can not always be as easy as the previous guiding questions. If all guiding questions are as easy as the example, then the students will fully depend on those questions and can not understand how to solve the HOTS question. To avoid student dependence on our scaffolding, we provide three levels of scaffolding, which we will elaborate in the next section.

1. Development Process using ADDIE

This research is development research using the ADDIE concept. ADDIE is an acronym for Analyze, Design, Develop, Implement, and Evaluate [27]. At the analyzing stage, we carry out curriculum and literature analysis, target analysis (students), material analysis, and analyze the resources needed. At the design stage, we determine the type of product that is going to be developed, designs a flowchart, collect ideas from similar products on the market, designing the media, arrange materials, and arranges instruments. At the development stage, we make the prototype and carry out trials. At the implementation stage, we implement the media we made and collect feedbacks from research subjects. Evaluation is done at each other stages. After implementing the media, we do the final evaluation before releasing our media to the public.

 The detail of each step, except for the evaluation, is elaborated in the following subsections. The evaluation was done when needed. We test the effectiveness of our media by comparing the SRL of the junior high school students who used our media (experimental class) and their peers who did not (control class). The experimental class consisted of 30 students, while the control class consisted of 32 students. We measure the SRL by giving them a 5-level Likert scale questionnaire. The mathematics topic used in this research is the system of linear equations in two variables.

* 1. Analyze

We began our research by deciding the topic, which is the improvement of SRL. Our next step is deciding on the subject of our research. After we got the participants, we ask them what makes them do not want to learn by themselves, i.e., why they do not engage in SRL. Their answers can be seen in table 2. We evaluate their reasons and found that indeed, those reasons affect some SRL indicator negatively. Thus by addressing those reasons, we can help to facilitate the students SRL.

|  |  |
| --- | --- |
| **Reasons** | **SRL Indicators** |
| They don’t know how to solve the questions. | Cognition – planning |
| Time control is difficult when studying alone for them. | Behavior – monitoring |
| They are tempted to copy friends’ answers as the questions are the same. | Behavior – control |
| Sometimes the topic is difficult for them. | Motivation – planning |
| When learning outside, the math book isn’t flexible to be carried around. But they can’t use the internet because the information too much. | Cognition – planning |
| Sometimes the questions can be too easy for them. | Cognition and motivation – monitoring |
| They don’t know their score. | Cognition and motivation – reflecting |
| When doing practice questions/homework, they don’t know whether their answer is correct or not. | Cognition – reflecting |
| They can’t choose the right questions for test the ability in a topic. | Cognition – reflecting |

Table 1

* 1. Design

Based on the results of questionnaires from students, our media is made with the following considerations. *First,* it must be in the form of online digital media. By making the media online, we can make the media provides the answer to a question only after the students try it. If we use paper, we have only had two choices; either give them all the correct answers or not at all. If we give them the correct answer, then they can be tempted just to see all the answers without trying. But if we do not give them the answer, they can not review their mistakes. The correct answer for the reviewing process is very important when they learn at home and can not discuss it with their teacher.



Figure 2 Home page (left) and the scaffolding levels (right)

 By using online digital media, we also can give different homework to each student by utilizing a database. When each student does their homework, they get randomly chosen questions from the database, resulting in each student has different homework from their friends. As a result, it is harder for them just blatantly copying other’s homework. The last advantage of using online digital media is that we can easily put a timer in it, and we can also give the students their score easily.

 *Second,* it must contain scaffolding so that the students can solve the problems while also learning it. The scaffolding we used in this research is fixed scaffolds in the form of guiding questions.

With the help of the guiding questions, we can help the students to answer the questions beyond their ability. But it is important to note that the scaffolding must be delivered without the help of the teacher. The reason is that the student mainly engaged in SRL in their home without the presence of their teacher. This strengthens our choice of using online digital media.

 Students feel that some questions are too easy, while some are too hard. This fact, along with the notion that scaffolding must only be a temporary welp, we make three levels of the guiding questions, with each level contain various difficulty levels of mathematics questions. Using the question in example 1, we will show the main difference between each level. It is important to note that the questions in our media are not limited to word problems. But for the sake of clarity, we argue that it is easier to explain the difference between each level by using a word problem.

|  |
| --- |
| *The height of a water rocket measured from ground level is expressed in the equation* $h=xt-yt^{2}$ *with* $h$ *is the rocket height (*$h>0$*) in meters, and t is the time elapsed since the rocket launched in seconds. If 1 second after launching the rocket reaches a height of 10 meters, and after 2 seconds, the rocket reaches a height of 16 meters, determine the height of the rocket 3 seconds after launching!* |

Table 1 Example 1

 The lowest level of the guiding questions is, “Let’s learn!” (example picture can be viewed in subsection 3.5). For “Let’s learn!” we make the guiding questions as detailed as possible. The steps to solve example 1 are usually: 1) substitute $t$ by 1 and 2 to get two linear equations, 2) solve for $(x,y)$ and substitute it to $h=xt-yt^{2}$, and 3) use the new equation to answer the question. In “Let’s learn, we break both steps into these guiding questions.

1. Substitute $t$ by $1$. What equation do you get?
2. Substitute $t$ by $2$. What equation do you get?
3. Based on the previous questions, what linear equations system do you have now?
4. If you multiply the first equation by 2, what equation do you get?
5. If you subtract the first equation by the second equation, what do you get?
6. What is the value of $y$?
7. By substituting the value of $y$ to one of the equations, what is the value of $x$?
8. Substitute the value of $x$ and $y$ to $h=xt-yt^{2}$. What equation do you get?
9. Using the answer from the prev equation ($h=12t-2t^{2})$, what is the value of $h$ if $t=3$?
10. What is your conclusion?

After they reach guiding question 3, they will get two equations, $x-y=10$ and $2x-4y = 16$. To solve this system, we combine the elimination and substitution process, as shown in the guiding question 4 to 7. Note that for other questions, we may eliminate $y$ first, or using elimination to find both $x$ and $y$, or multiply the second equation instead of the first equation, or other possible ways to solve the system. We want the student to understand that there are many ways to solve it. After finding $x$ and $y$, the rest of the guiding questions guide them to find the answer.

 As can be seen in the guiding questions, all of them are direct questions that do not require deep thinking from the students. By solving all the guiding questions, it is guaranteed that the students will get the answer as long as they master the basic algebra. They do not necessarily need to understand what they are doing by solving each question. Because of that, we provide an explanation in each of the guiding questions about what they are doing by solving a guiding question.

 The middle level of the guiding questions is, “Let’s practice!” (the picture can be viewed in subsection 3.5). For the “Let’s practice!” we reduce the support given to the students. We still provide the guiding questions, but not as detailed as the previous level of scaffolding. We only provide a hint for each guiding question, and the students have to think themselves. For example 1, these are the guiding questions if we use the scaffolding in “Let’s practice!” scaffolding.

1. By substituting the value of $t$ to $h=xt-yt^{2}$, what linear equations system do you get?
2. By using the linear equations from the previous question, from the following choices, which choice is the correct steps to solve if for $x$ and $y$?
3. What is the value of $x$ and $y$?
4. Substitute the value of $x$ and $y$ to $h=xt-yt^{2}$. From the resulting equation, how do you find the height of the rocket if the time elapsed is known?
5. What is your conclusion?

As seen in the guiding questions, the guiding questions are not as direct as the previous level. Take the guiding question 1 for the example. To answer this question, the students have to think, which value of $t$ that they need to substitute? Do they have to choose one value, or do they have to substitute both values? How many equations that they need? After working on “Let’s learn!” they should have a basic understanding that the system must contain at least two equations, so in “Let’s practice!” we test that understanding.

 At this level, we also change how we ask the guiding question. Take the guiding question 2 for the example. This is not a direct question, but instead, the students have to evaluate the choices. We argue that asking these kinds of questions will help the students to spot a mistake in their work while also helps them to recall and remember the necessary steps.

 For the last level, “Quiz? I’m not afraid!” the students do not get hints (the picture can be viewed in subsection 3.5). The guiding questions only serve as the direction to solve the HOTS question. By working on HOTS questions in the two previous levels, aside from basic understanding, the students should be used to think about a guiding question by themselves. So, if the HOTS question in example 1 are given in “Quiz? I’m not afraid!” the guiding questions are:

1. What linear equations system do you get from the question?
2. What is the solution for the linear equations?
3. How do you find the height of the rocket if the time elapsed is known?
4. What is your conclusion?

Aside from how the guiding questions are given, other differences between each level include 1) timer, 2) explanation for the answer, 3) explanation about the guiding questions. Those differences between each level can be seen in the following table.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Let’s learn | Let’s practice | Quiz |
| Guiding questions amount | Maximum | Just enough | Minimum |
| Timer | No | Yes (longer) | Yes (shorter) |
| Correct answer and its explanation | Always | Only given when students give the wrong answer | Only correct answer without an explanation |
| An explanation about the guiding question | Yes | No | No |

Table 2 Differences our between scaffolding levels

We use a timer to make the students used to solve a problem within a time frame. In “Let’s learn!” we do not use it because the main function of this level is for them to learn. They need to be used to the topic first. The correct answer and its explanation are not always needed. For “Let’s learn!” we always give the students the explanation because, once again, we expect them to learn. After getting used to the topic, reading an explanation after the correct answer will only bore the students sometimes unneeded; hence we only give it for the wrong answer. For “Quiz? I’m not afraid!” we do not give them an explanation for the correct answer because we want to let them think themselves, how do they reach the right answer.

* 1. Development

Based on our design, make our online digital media in the form of a webpage. We tested our prototype to some students and got some valuable feedback. First, some bugs needed to be fixed; for example, some internet providers could not open the webpage. Second, the font size is too big. Third, the instruction on how to use the media must be seamlessly included in the media, not provided separately as a manual sheet. Fourth, the webpage must be optimized more for the smartphone, as the students mainly use a smartphone to access the web, not a laptop. Fifth, they gave us their suggestion about how long the timer for each level should be. We then revise our online digital media accordingly.

* 1. Implementation

Along the process of implementing the media, we got some valuable feedback from the students. First, there are still some minor some technical issues, such as an answer marked as the wrong answer when the explanation said otherwise. Second, some explanation is too long. The students feel the explanation can be shortened. Third, the explanation about what the students do by solving each guiding question should be optional to be shown because it makes their screen filled with too much text. Fourth, the scaffolding must be an optional option. They want to turn it off when needed but still can access it if needed. During the implementation process, we make changes according to the first three feedbacks from the students immediately. But for the fourth feedback, we evaluated it first before making any change because it will make a drastic change to our media.

* 1. (Final) Evaluation

We decide not to make any change regarding the fourth feedback in the previous subsection as after inspecting about it, we find that only a few students ask for it. We also find that those students are high achievement students who naturally need little help in solving the mathematics questions. With that suggestion rejected, there is no change in our core design.

 After discussing it with the students who gave the feedback, they suggest that if their suggestion is not feasible, we should provide one more ‘level’ in which the questions inside do not have any scaffolding at all. We decide to accept that suggestion. Note that this ‘level’ is not included as scaffolding, as it contains only questions.



Figure 3 “Let’s Learn!” (left) and “Quiz? I’m not afraid” (right) after evaluation

 At this stage, we also take a look at the effectiveness of our media. In this research, our null hypothesis is the SRL score of the students in the experimental class is not higher than the SRL score of the students in the control class. The alternative hypothesis is the SRL score of the students in the experimental class is higher than the SRL score of the students in the control class. We used the Mann-Whitney U test because the data from each class is ordinal, independent of each other, and have the same distribution shape. The confidence interval is 5%. Based on the output, $p-value=0.007222,$ which is smaller than $0.05$. Thus we reject the null hypothesis and accept the alternative; the SRL score of the students in the experimental class is higher than the SRL score of the students in the control class.



Figure 4 Output R

1. Discussion

The result shows that compared to the control class, the experimental class has a better SRL score. Based on it, we can safely assume that by using our scaffolding-based online digital media, the students SRL can be facilitated better. It happened because we solve their problem when studying on their own by giving them scaffolding through our online digital media. Our research supports that fixed scaffolds integrated into technology can help to facilitate students’ SRL levels [28–30].

 Students generally felt helped by the media, but there was dissatisfaction both in content and from a technical point of view. In terms of content, students do not like long explanations. We assume that students were not used to or did not like long texts, or that students did not like reading at all. This assumption is reinforced by the research of [31], showing a tendency that students do not like questions with long texts. We think it is important to test this assumption, as we need to know whether Indonesian students like reading or not.

 From a technical point of view, some students do not understand how to do common things such as registering their account and logging in to their account. The number is not large, but this indicates that even for an urban area like Yogyakarta, maybe not all students have a sufficient level of technological skill. It is worth investigating the level of students’ technological literacy and readiness, especially with the increasing trend to integrate technology into classroom learning. If technology is directly integrated without knowing the readiness of students, technology will not have a good impact on student development.

1. Conclusion

Based on previous sections, we conclude that for developing a media for facilitating SRL, these features/characteristics can facilitate students SRL. *First*, the media is integrated with scaffolding, as scaffolding can help the students to solve questions beyond their ability. *Second,* we provide three levels of scaffolding, so the help that the students got can gradually be decreased. *Third,* we also provide various levels of difficulty. *Fourth*, it can be in the form of online media, as it still can help the students without the presence of the teacher. *Fifth*, it must display the students’ score immediately and also gives them the correct answers and the explanation. *Sixth,* it must have a timer so the students can be trained to solve a question within a time limit.

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