Constructionist Approach Instructional Model in the Digital Learning Ecosystem to Promote Self-Directed Learning Skills

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Abstract—In the 21st century, advancements in technology have constantly been the driving force behind the discovery and transformation of information and knowledge. In this context, self-directed learning (SDL) skills are essential in becoming a lifelong learner. Consequently, education plays an important role in promoting SDL skills and preparing students for work and life in this century. For these reasons, this study presented research questions that led to the development of an instructional model that promotes SDL skills using a constructionist approach within the digital learning ecosystem (DLE). The methodology used in this research consisted of two types of instructional model design: model development and model validation. The development of a constructionist approach instructional model in the DLE was based on reviews of relevant literature, and model validation was conducted with the help of experts. The results of the study showed that the developed instructional model is effective in promoting SDL skills and can be applied in practice.

Keywords—constructionism, digital learning ecosystem, self-directed learning

1 Introduction

Since the beginning of the 21st century, the world has been changing dramatically and has transformed into a globalized society because of the advancement of information communication technology (ICT). This has significantly affected various dimensions of people's daily lives. The ways that people think, learn, and communicate are different from how they were in the previous century. Technology is the driving force behind new discoveries, changes in information, and the emergence of new knowledge. Therefore, it can be said that society has developed into an information and knowledge society [1]. The "half-life of knowledge," which refers to the amount of time that elapses between when knowledge is established and when it becomes obsolete [2], became significantly shorter after the introduction of the internet compared to that of the time when radio was invented [3]. The constant acquisition of new knowledge and skills has become increasingly important in this century [4]. Self-directed learning (SDL) is fundamental to being a lifelong learner [5]. Students with SDL skills are motivated

to take responsibility and have self-control when it comes to setting and managing their formal and informal learning to acquire up-to-date knowledge, skills, and competencies [6][7][8], making SDL skills extremely important in a world in which the half-life of knowledge is rapidly shortening. Therefore, education has a duty to promote SDL skills to prepare students for work and life in the 21st century [9]. During the Covid-19 pandemic, more than ever, SDL has been proven to be a critical factor in students' learning achievement [10].

Currently, it is accepted that ICT is an effective educational tool [11] that increases virtual learning opportunities in the form of a digital learning ecosystem (DLE) [6]. ICT provides students with convenient access to information that encourages SDL skills [7]. However, appropriate teaching strategies are required to develop such skills [12]. These strategies should encourage students to actively participate in the learning process and to take responsibility for their assigned tasks, and teachers support students to achieve effective learning [13][14]. The necessary teaching strategies are consistent with the concept of constructionism, which emphasizes the students' role in learning as that of designers [15]. Therefore, the following research questions related to promoting SDL skills using the constructionist approach instructional model in the DLE were raised.

1) What are the components of the constructionist approach instructional model in the DLE?
2) How suitable are the components of the constructionist approach instructional model in the DLE?
3) Can the constructionist approach instructional model in the DLE be used to develop SDL skills?

The results of this study can provide teachers and educators with guidelines regarding designing teaching and learning activities based on constructionism and using ICT tools as learning tools in the DLE to develop students' SDL skills. In addition, the SDL skills components identified in this study will provide a conceptual framework that can be used by teachers and educators to develop SDL skills assessment tools.

2 Literature review

2.1 Constructionism

Constructionism, a learning theory that was built on Piaget's constructivist theory, suggests that knowledge cannot be transferred from teachers to students. Rather, knowledge must be constructed by the students themselves. Papert [16] stated that knowledge is constructed by building artifacts. Rob and Rob [17] explained that although students are building artifacts, they can show, and share these artifacts with their peers, making learning meaningful. This is considered an important factor that affects students' learning. Apart from constructing new knowledge by themselves, they create a motivation cycle that would propel them toward constructing increasingly complex knowledge. Zadelhof, Rahimi, and Barendsen [18] stated that learning occurs when students experience challenges when it comes to developing artifacts. Monga et al. [19] introduced

a learning process by creating artifacts that consist of the following: 1) students imagining what they want to do, 2) creating something based on their ideas, 3) playing with what they have created, 4) sharing ideas and artifacts with others, and 5) reflecting on their experiences and getting feedback. In addition, Han and Bhattacharya [20] suggested that investigation and problem solving are important components of the constructionist learning process. In addition, Techakosit and Nilsook [21] asserted that design is an essential part of the construction process. Charles and Rankin [22] advocated that artifacts designed, created, validated, and revised by students help them make connections between prior and new knowledge. It can be seen that the constructionist approach to the instructional process puts emphasis on students' learning through the artifact-making process. The process includes building challenges as well as designing, creating, and presenting artifacts for assessment and that of the learning experiences. The results of the literature review provide a framework for the development of the constructionist instructional process.

2.2 Digital learning ecosystem

Studies and research on the application of ICT or digital technology in primary to higher education have been conducted extensively since 1980 [23]. Teachers integrate digital technology into their teaching and learning to improve their own teaching and to effectively assess students' learning. ICT is also used to facilitate communication between teachers and students as well as among students, making their learning environment a DLE [24], an aspect that is essential in enhancing the quality of instruction in the digital age [25]. In addition, the DLE provides a learning tool for students to seek advice and reports on their academic progress [26]. An ecosystem is a well-known, general term in biology that refers to a network of biotic and abiotic components in an environment that depend on and interact with one another [27]. In the case of the DLE, Ali et al. [28] stressed that students are not the only components of the DLE; other learning tools are also key components. The authors of the study in [24] suggested that the DLE is similar to an ecosystem. It also consists of two main components: biotic components, such as teachers, students, tutors, and online learning facilitators, and abiotic components, such as computers, and mobile phones. In addition, Nguyen and Tuamsuk [25] argued that in addition to the biotic and abiotic components, there is another component, which is the interaction among the components in the DLE. Ficheman and Lopes [29] proposed that within the DLE, there are relationships between biotic components, particularly the interactions between the two main species—the human species and the digital species—which makes up the content. The abiotic components in the environment such as hardware, software, and the internet, as well as pedagogies, are the components that support the interactions between the biotic components. It can be seen that the DLE consists of biotic components such as students, teachers, and external experts, all of whom play a role in the teaching and learning process. In conjunction with this, there are abiotic components, such as content and digital technology, which create a learning environment that supports learning and the interaction between the individual units of the biotic components.

2.3 Self-directed learning

There are two different major perspectives on SDL. Some educators view SDL as a teaching and learning process, whereas others view it as a personal attribute [30]. In this study, the view of SDL as a personal attribute is adopted because we expect students to be encouraged by the constructionist approach instructional model in the DLE. To understand SDL skills more, it is important to review the literature on the aspects that constitute SDL skills. Several educators have described these various ability aspects. Kicken et al. [31] suggested that SDL skills consist of three competencies: the ability to self-assess performance, the ability to determine learning needs, and the ability to select learning tasks. In addition, Tekkol and Demirel [5] concluded that SDL skills include the ability to identify one's own learning needs, the ability to use a variety of learning strategies, the ability to manage time effectively, and the ability to evaluate one's own learning. According to a study by Toit-Brits [32], students with SDL skills must have the ability to a) initiate self-learning, b) learn without the help of others, c) identify their own learning needs, d) articulate their own learning goals, e) utilize appropriate learning strategies, f) self-assess their learning, and g) practice social and interpersonal skills, etc. Bhandari, Chopra, and Singh [33] assessed SDL skills by examining students' learning motivation, learning management ability, and communication ability. The findings of the abovementioned studies led to the conclusion that SDL skills include a number of competencies such as the ability to motivate learning, the ability to use learning strategies, and the ability to assess one's own learning. This result will be used as a framework for constructing a questionnaire for assessing SDL skills.

3 Methodology

Research regarding the instructional model design can be divided into three aspects: model development, model validation, and model use [34][35]. This study relates to the first two aspects: model development and model validation. It can therefore be divided into two phases as follows:

Phase 1: Design and development of the constructionist approach instructional model in the DLE to promote SDL skills. This involved the following:

- Synthesizing documents related to the constructionist instructional process, including the works of Zadelhof, Rahimi, and Barendsen [18], Monga et al. [19], Han and Bhattacharya [20], Techakosit and Nilsook [21], Charles and Rankin [22], and Jalinus, Nabawi and Mardin [36].
- Reviewing literature related to the DLE, including the works of Reyna [24], Ficheman and De Deus Lopes [29], Jeladze, Pata, and Quaicoe [37], García-Holgado and García-Peñalvo [38], and Brown et al. [39].
- Studying the concept of SDL skills based on the works of Morris and Rohs [7], Robinson and Persky [13], Song and Hill [30], Kim and Lee [40], Mahlaba [41], Tohidi et al. [42], and Moradi [43].

– Applying the findings from literature reviews and document synthesis to design a prototype of the constructionist approach instructional model in the DLE to promote SDL skills.

Phase 2: Validation of the constructionist approach instructional model in the DLE to promote SDL skills. This involved the following:

– Presenting the prototype to seven experts, all of whom were lecturers in higher education with doctoral degrees and had at least 5 years of expertise and experience in instructional design. An instrument for validation was developed for these experts to assess the suitability of the prototype of the instructional model. The instrument consisted of five-point Likert scale questions (1 = extremely unsuitable; 5 = extremely suitable) and open-ended questions to elicit the experts' opinions. The instrument's internal consistency or reliability was measured using Cronbach's alpha coefficient. The result showed that the instrument was reliable as it had a Cronbach's alpha value of .97, and the generally accepted conformity level is ≥.70 [44].
– Using descriptive statistics, namely, mean, and standard deviation, to analyze the quantitative data collected from the experts using the instrument for validating the suitability of the instructional model. The criteria used for interpreting the mean scores [45] were as follows:

$$RS = \frac{HV - LV}{NS} = \frac{5-1}{5} = 0.80$$

where *RS* means range of suitability, *HV* means the highest value, *LV* means the lowest value, and *NS* means the number of suitability levels. Mean scores ($\bar{x}$) in the range of 1.00–1.80 were interpreted as extremely unsuitable; those in the range of 1.81–2.60, as rather unsuitable; those in the range of 2.61–3.40, as neither suitable, nor unsuitable; those in the range of 3.41–4.20, as rather suitable; and those in the range of 4.21–5.00, as extremely suitable.

The constructionist approach instructional model in the DLE to promote SDL skills has been developed to be more comprehensive with the guidance of experts.

4 Results

The results of this study are reported in terms of the three research questions as follows:

Question 1: What are the components of the constructionist approach instructional model in the DLE?

From the synthesis of related documents, it was found that the constructionist approach instructional model in the DLE to promote SDL skills consists of 1) the constructionist instructional process, 2) the DLE, and 3) SDL skills as shown in Figure 1.

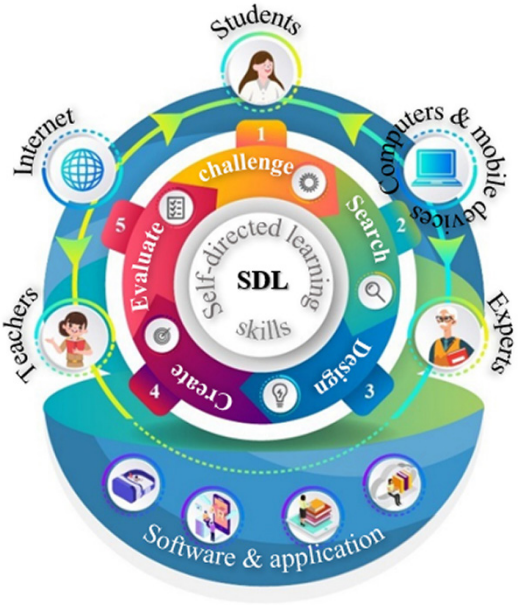

Fig. 1. Constructionist approach instructional model in the DLE to promote SDL skills

The synthesis of the literature revealed that the constructionist instructional process consists of five stages. The first stage, that is, challenge, involves building the inspiration to learn and encouraging students to participate in solving problems. The second stage, that is, search, involves the students searching for and gathering information and knowledge from various sources to find solutions to problems. The third stage, that is, design, involves the students generating a prototype to solve problems in terms of the limitations and conditions specified. The fourth stage that is, create, involves the development of artifacts from a prototype that has been tested and improved to meet the specified limitations and conditions. The fifth stage, that is evaluate, involves the presentation of the artifacts and reflecting on what has been learned during the artifact development process.

The synthesis of the literature related to the DLE revealed that the DLE consists of two main components: biotic components, which are components that play roles in teaching and learning, such as students, teachers, and external experts; abiotic components, which are digital tools that support formal and informal learning, such as computers, the internet, and software. In addition, a key characteristic of the DLE is that it is a learning environment that is designed to use the necessary digital resources to provide students with the motivation to learn, facilitate access to new information and knowledge, and provide tools for creating work and assessing students' learning.

The synthesis of the literature related to SDL skills revealed that SDL skills consist of three abilities: 1) the ability to be a self-motivated learner, which includes the ability to develop awareness regarding meaningful learning for oneself and the responsibility to plan and set learning goals; 2) the ability to learn efficiently, which involves the

ability to select and employ appropriate learning strategies while being independent and determined to work toward success and to achieve set goals; and 3) the ability to self-assess one's learning, which involves the ability to self-monitor and self-assess one's learning with confidence.

Question 2: How suitable are the components of the constructionist approach instructional model in the DLE?

The results of the assessment of the suitability of each stage in the instructional process are as follows:

Table 1. The results of the assessment of the suitability of the constructionist instructional process

Constructionist Instruction	$\bar{x}$	S.D.	Interpretation
Challenge	4.86	0.38	extremely suitable
Search	4.86	0.38	extremely suitable
Design	4.86	0.38	extremely suitable
Create	4.86	0.38	extremely suitable
Evaluate	4.71	0.49	extremely suitable

The assessment on the part of the experts showed that they deemed the overall instructional process to be extremely suitable ($\bar{x}$ = 4.83, S.D. = 0.38) as shown in Table 1. Individually, the stages of challenge, search, design, and create were deemed to be extremely suitable ($\bar{x}$ = 4.86, S.D. = 0.38) and the evaluation stage was found to be extremely suitable ($\bar{x}$ = 4.71, S.D. = 0.49).

Table 2. The results of the suitability assessment of the main components and the key characteristics of a DLE

Digital Learning Ecosystem	$\bar{x}$	S.D.	Interpretation
A digital learning ecosystem consists of biotic and abiotic components.	4.86	0.38	extremely suitable
It is a learning environment that puts emphasis on the interaction among components.	4.86	0.38	extremely suitable

According to the results shown in Table 2, the classification of the DLE components as biotic and abiotic was seen as extremely suitable ($\bar{x}$ = 4.83, S.D. = 0.38) and the key characteristic of the DLE was deemed extremely suitable ($\bar{x}$ = 4.83, S.D. = 0.38).

Table 3. The results of the suitability assessment of the elements of SDL skills

Self-Directed Learning Skills	$\bar{x}$	S.D.	Interpretation
The ability to be a self-motivated learner	4.86	0.38	extremely suitable
The ability to learn efficiently	4.86	0.38	extremely suitable
The ability to self-assess one's learning	4.86	0.38	extremely suitable

As shown in Table 3, it was found that the three abilities of SDL skills, which are the ability to be a self-motivated learner, the ability to learn efficiently, and the ability to self-assess learning, were assessed as being extremely suitable ($\bar{x}$ = 4.83, S.D. = 0.38).

Question 3: Can the constructionist approach instructional model in the DLE be used to develop SDL skills?

An assessment by experts will help in answering the question as to whether or not the constructionist approach instructional model in the DLE is suitable for developing SDL skills and in assessing the feasibility of using it in a real classroom.

Table 4. The results of the suitability assessment of the instructional model for real classroom application

Evaluation Item	$\bar{x}$	S.D.	Interpretation
This instructional model is suitable for promoting the ability to be a self-motivated learner.	4.86	0.38	extremely suitable
This instructional model is suitable for promoting the ability to learn efficiently.	5.00	0.00	extremely suitable
This instructional model is suitable for promoting the ability to self-assess one's learning.	5.00	0.00	extremely suitable
This instructional model is suitable for promoting self-directed learning skills.	5.00	0.00	extremely suitable
This instructional model has the potential to be used in practice.	5.00	0.00	extremely suitable

Table 4 shows that the constructionist approach instructional model in the DLE is extremely suitable for promoting SDL skills ($\bar{x}$ = 5.00, S.D. = 0.00). When considering each SDL skill individually, this instructional model is found to be extremely suitable for promoting the ability to be a self-motivated learner ($\bar{x}$ = 5.00, S.D. = 0.00), promoting the ability to learn efficiently ($\bar{x}$ = 5.00, S.D. = 0.00), and promoting the ability to self-assess one's learning ($\bar{x}$ = 5.00, S.D. = 0.00). In addition, the experts agreed that this instructional model is extremely suitable when it comes to being used in practice ($\bar{x}$ = 5.00, S.D. = 0.00).

5 Discussion

In this study, we hypothesized that suitable instructional strategies such as the constructionist approach and an ecosystem that supports learning with digital tools can have a positive impact on students' SDL skills. The instructional design model was used as the research methodology, and the study was divided into two phases. The results of the first phase or model development phase showed that the constructionist approach instructional model in the DLE to promote SDL skills consists of 1) a constructionist instructional process involving challenge, search, design, create, and evaluate, and 2) the DLE is a learning ecosystem that uses digital tools to support both teachers' teaching and students' learning. In addition, SDL skills consist of three abilities: the ability to be a self-motivated learner, the ability to learn efficiently, and the ability to self-assess learning. The results of the second phase consisting of model validation showed that all three components of the constructionist approach instructional model in

the DLE to promote SDL skills were assessed as being extremely suitable. The results of this study confirm the finding of Roberson [8] and Zarouk et al. [46] that students' SDL skills can be promoted by project-based learning, as well as those of Techakosit and Nilsook [47], who stated that the learning process involving Knowledge and creating artifacts using digital tools can promote the ability to search for new knowledge. With similar instructional activities, it can also promote life skills, including lifelong learning skills [48]. Mariana [49] also emphasized that integrating a constructionist approach with the use of digital technologies reduces the role of teachers and expands the role of students in the teaching and learning process, and increases the importance, and benefits of education in this century. ICT, an essential component of the DLE, reduces time and place constraints as ICT extends learning beyond the classroom and allows students to have access to learning resources at any time and in any place and encourages students to work collaboratively. However, Papadakis [50] argued that technologies must be well designed to enable the creation of meaningful and powerful tools for student use.

6 Conclusion

The main objective of this study is to develop a constructionist approach instructional model in the DLE to promote SDL skills. The methodology used involved the first two types of instructional model design: model development and model validation. The result of the model development phase showed that, according to constructionism, the instructional process consists of the following five stages: challenge, search, design, create, and evaluate. It was also found that the DLE consists of biotic and abiotic components and those abiotic components are the technologies that support the learning of biotic components. SDL skills include the ability to be a self-motivated learner, the ability to learn efficiently, and the ability to self-assess learning. The validation of the constructionist approach instructional model in the DLE to promote SDL skills revealed that the developed instructional model is effective in terms of developing SDL skills and can be used in practice.

7 Limitations and further studies

In this study, only model development involving synthesizing related documents and the use of model validation phases were conducted. Therefore, the outcome was the creation of a concept for developing instructional activities that are in line with constructionism in the DLE and an SDL skill conceptual framework. In addition, the validation of the model was conducted by relying on the expertise and experience of experts. As a result, this study still lacks consideration of the model's application in real classrooms and both context analysis and learner analysis, both of which are important for teachers who will employ this instructional model. In future research, we will evaluate the effectiveness of the model use phase in actual classrooms. It is hoped that the results of such a study can be used as a conceptual framework for creating detailed instructional activities and for developing an SDL skill evaluation form.

8 References

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