DEVELOPMENT OF ADAPTIVE INSTRUCTIONAL SCAFFOLDING ON ONLINE FORUM DISCUSSION TO IMPROVE PERSONALIZATION IN MOOCS LEARNING ENVIRONMENTS

Saida Ulfa, State University of Malang
Ence Surahman, State University of Malang
Izzul Fatawi, Universitas Terbuka, Indonesia
Tsukasa Hirashima, Hiroshima University

ABSTRACT

There are many problems faced by students in an online discussion forum, specifically regarding platforms that accommodate a large number of students such as the Massive Open Online Courses (MOOCs) platform. One of the problems is that the teacher cannot respond one by one to student comments that may contain questions or ideas. Therefore, the objectives of this research were to develop an adaptive instructional scaffolding feature that can be applied to online discussion forums and to perform usability measurements for this scaffolding. This feature provides an immediate response to student posts in the discussion forum in the form of article recommendations sourced from the Scopus database. These recommendations are based on the students' comments posted on online discussion forums. The development model used in this study is the instructional model ADDIE (Analyze, Design, Development, Implementation, Evaluation). To test the usability of the developed features, usability measurement using the usefulness, satisfaction, ease of use (USE) questionnaire was employed. The survey was conducted with 137 students at a public university in Indonesia. The results of the measurement showed that the usability level of the features we developed was shown to be high.

Keywords: *adaptive learning, adaptive instructional scaffolding, online discussion forums, personalized learning, MOOCs*

INTRODUCTION

The use of online learning has increased significantly in recent years (Brika et al., 2022; Shen et al., 2022). Many institutions, especially in higher education, have combined online and face-to-face learning delivery. However, given the widespread use of online learning, the personalization factor in learning is still a problem. This can be seen from the learning designs presented in online learning that tend to be uniform or one size fits all, where the offered learning strategies do not accommodate the individual needs of students (El-Sabagh, 2021).

Personalized recommendations or personal recommendations can be categorized as one instructional scaffolding (Goller & Paloniemi, 2017). This personal recommendation is very important for online learning students because of the large amount of learning material that they must read, so it is sometimes difficult for students to choose what to read (Liu et al., 2018), therefore

recommendations for suitable learning materials for students can be very helpful.

Online learning that uses a Learning Management System (LMS) provides features, such as a discussion forum, that can promote the interaction between teachers and students or among students, though this does not automatically increase the interaction between students (Cerezo et al., 2016), in this case.

One example of an asynchronous learning mode in an online learning environment is a discussion forum. In general, discussion in a forum is very difficult to implement because there must be mutual interaction among participants. The discussion forum is a significant feature in all LMSs and has been used as an online learning feature for decades since the 1990s to increase engagement, motivation, and reflection, and thereby lead to deeper learning (Onah et al., 2014). A discussion forum is limited to written language interactions (Ak, 2016) where all students are expected to carry out written interactions, know how to write down their ideas, and respond to other students' ideas. Thus, in a discussion forum there is a lot of information that contains students' questions and ideas. When a problem arises in the discussion forum, it can either be solved together by the students or they can wait for the instructor or teacher to provide a solution to the problem.

Another problem arises in discussion forums, especially for the MOOCs platform that accommodate a large number of students and a proportionate number of posted comments in the discussion forum. The existing MOOCs platforms do not have instructional scaffolding facilities that can help instructors provide immediate responses related to discussions being carried out by students (Pérez-Sanagustín et al., 2021). One solution is to provide an intelligent system that can deliver personalized learning (Gynther, 2016; Tang, 2016) and provide different immediate feedback in real time to students.

In order to provide adaptive instructional scaffolding in the online discussion forum in a MOOCs platform, the research objectives of this study were to design and develop adaptive instructional scaffolding features that can increase personalized learning and to carry out usability measurements of the product we developed.

LITERATURE REVIEW

Instructional Scaffolding

Instructional scaffolding is a systems approach designed to help students improve their cognitive abilities when solving ill-structured problems (Belland et al, 2017a). In practice, instructional scaffolding can help students quickly and accurately find the right instructions according to their learning needs through interactions in their online learning environment system. Instructional scaffolding was developed to attract interest in learning and maintain student engagement (Belland et al., 2013). Online interactions such as live chat, video conferencing, and online discussion forums provide opportunities for interaction between students and teachers through synchronous and asynchronous modes. The online discussion forum has advantages in terms of opportunities to reflect back or make drafts in written communication and reflection (Verenikina et al., 2019). When combining asynchronous and synchronous modes, opportunities are created for students to learn through dialogue that incorporates reflection on content and communication strategies. The utilization of a "mixed mode" approach presents distinct possibilities for learning through discourse that encompasses both critical analysis of the subject matter and the development of effective communication methods (Hull & Saxon, 2009).

When students learn something new or study material that is difficult, they need help in learning. Scaffolding, in the form of assistance or support in learning, is gradually reduced to transition learning responsibility from the teacher to the students. One-to-one scaffolding encompasses several instructional strategies such as modeling, questioning, explaining, offering suggestions, and delivering feedback (van de Pol et al., 2010). When a student's learning performance indicates no progress, scaffolding can be used and if a learner's performance shows good progress, scaffolding can be disguised (Belland et al., 2017b). In addition, a scaffolding can be added in an intelligent tutoring system (Belland et al., 2017a).

Sociocultural theory allows for the conceptualization of effective social interaction in terms of the idea of scaffolding (Verenikina, 2008), collaborative reasoning (Mercer & Howe, 2012), and constructing knowledge in an online environment (Delahunty, Jones et al., 2014; Delahunty,

Verenikina et al., 2014). This theory posits that the utilization of scaffolding techniques can facilitate students in effectively navigating challenges pertaining to content knowledge, knowledge transfer, and motivation within the context of problem-based learning (Schmidt et al., 2011).

The utilization of instructional scaffolding is a crucial mechanism in providing assistance to students when they experience challenges throughout the process of acquiring knowledge (Choo et al., 2011; Schmidt et al., 2011, 2019). In the context of online learning, scaffolding typically pertains to the utilization of technological tools by educators or instructors to provide instructional assistance and support to learners. The teacher can use various types of technological devices to assist students in learning. This is what motivates an online teacher to do scaffolding that matches the needs of students (Belland, 2014).

Instructional strategy based on fuzzy logic has been researched by Bhattacharya and Roy (2011), who developed intelligent scaffolding to help students achieve learning objectives through problem-based learning strategies. The applied fuzzy rule is used to predict the fuzzy agent based on feedback from the students. The effectiveness of computer-based scaffolding had also been studied by Kim et al. (2018), who focused on enhancing students' higher-order cognitive abilities within the framework of problem-based learning in the field of Science, Technology, Engineering, and Mathematics (STEM) education.

Personalization in Online Learning

The success of the learning process in an online learning environment depends on how it presents domain knowledge to students, content changes based on complexity and granularity in accordance with the progress of students, and the devices that will be used by students (Kinshuk, 2016). In addition, personalization and adaptability mechanisms require an environment that is expected to adapt seamlessly to the learning conditions of students anywhere and anytime (Kinshuk, 2016). Web-based learning is increasingly being accessed more and more via mobile devices. This is what supports the development of the smart learning system. Smart learning focuses more on technology-supported learning environments and on interactions between learners and the learning environment by implementing adaptations in learning that support context-based learning (Zhu et al., 2016).

Personalized elearning provides content or material recommendations tailored to individual needs. These recommendations are intended to help students process information gradually. Devedžić (2006) showed that personalization in online learning is education related to technology that creates a learning sequence for each learner based on their personal needs and preferred material (learning preference), and thus each individual receives different material according to their needs. The main reason for personalized learning is the belief that each individual is a unique being who has their own learning style. The concept of personalized learning comes from *Theory of Multiple Intelligences* by Howard Gardner (1987). Further, Cronbach (1957) said that the acquisition of learning outcomes is derived from the interplay between individual qualities and treatment variables. He proposed the implementation of differentiated instruction, which involves tailoring instructional methods to accommodate the unique cognitive talents of individuals. This hypothesis is the forerunner to the foundation of adaptive learning.

There are three things to be considered in adaptive learning according to Aroyo et al. (2006), namely: (a) what the material for adaptation will be, which is related to the Domain Module based on the parameters (i.e., according to what); (b) what the basis for adaptation will be, which is the Learner Module; and (c) how the adaptation results are presented, which is the pedagogical module and the adaptive engine system that will process the adaptation results. Thus, personalized learning entails the modification of pedagogical approaches, curricula, and learning environments in order to accommodate the specific needs and learning preferences of students (Baguley et al., 2014). Personalized elearning allows students to customize some of the elements of the online learning process (Klašnja-Milićević et al., 2016).

Online Discussion Forum in MOOCs

The discussion forum is a form of asynchronous mode in online learning. This is an important activity for increasing interaction and collaboration among students and between instructors and students. This particular feature has a range of benefits, such as fostering self-directed learning, enabling collaborative knowledge building, and enhancing critical thinking abilities (Wang & Woo, 2007; Yeh, 2010). It also provides an opportunity for

students to reflect on the answers and arguments given in the discussion so they can develop critical thinking and writing skills (Szabo & Schwartz, 2011). It also supports interactive learning and student-teacher communication (Onyema et al., 2019).

De Lima et al. (2019) also explained the difficulties faced by students and instructors when using educational online discussion forums, namely difficulties with the forum structure, lack of incentives, and difficulties with mentoring. In addition, sometimes instructors have difficulty compiling questions that elicit responses from students and sustain discussion without dominating the forum (Aloni & Harrington, 2018). Learning strategies are needed to improve educational online discussion forums, such as implementing gamification to increase student engagement, as has been implemented on the Stack Overflow platform (https://stackoverflow.com/). Further, Wise et al. (2016) developed topic auto classification to address overload issues in MOOC discussion forums.

METHODOLOGY

Research Model

Method used in this study is the ADDIE (Analysis Design Development Implementation Evaluation) model (Aldoobie, 2015; Branch, 2009). We selected the ADDIE Model to help us develop adaptive instructional scaffolding because ADDIE is one of the Instructional System Design models that has a systematic approach. A systematic process approach can assist in creating and developing effective instructional materials adapted to the learning environment (Aldoobie, 2015; Branch, 2009). The ADDIE model consists of five core stages, as shown in Figure 1.

Research Instruments

Measuring the usability of product development results in this study was carried out using the usefulness, satisfaction, and ease of use (USE) questionnaire developed by Lund (2001). This questionnaire is generally used to measure the usability of a product or service. According to Lund (2001), usability includes usefulness and ease of use. While the dimensions of ease of use are divided into ease of use and ease of learning, the dimensions in the USE Questionnaire had been previously defined by Davis (1989) in relation to user acceptance of information technology. Davis (1989) defined the concept of perceived usefulness can be defined as the extent to which an individual believes that utilizing a specific system will enhance their job performance or can be effectively utilized to their advantage. Also, Davis (1989) defined perceived ease of use as "the degree to which a person believes that using a particular system would be free of effort" (p. 320), which originates from the definition of the term as "freedom from difficulty."

The questions from the USE questionnaire can be seen in Table 1. The questionnaire requires participants to express their degree of agreement on a 5-point Likert scale including *strongly agree*, *agree*, *neither agree nor disagree*, *disagree*, or *strongly disagree*. There is one modified question (Q7) and two additional question items (Q8 and Q26) in this questionnaire.

FINDINGS AND DISCUSSION

Design and Development of Adaptive Instructional Scaffolding Discussions in a MOOCs Learning Environment

Adaptive Learning And Personalized Learning In Online Discussion Forums

Adaptive and personalized learning is gradually redefining the education landscape as it enables instructors to transform fixed learning into flexible

Figure 1.
ADDIE Model Phase (Aldoobie, 2015)

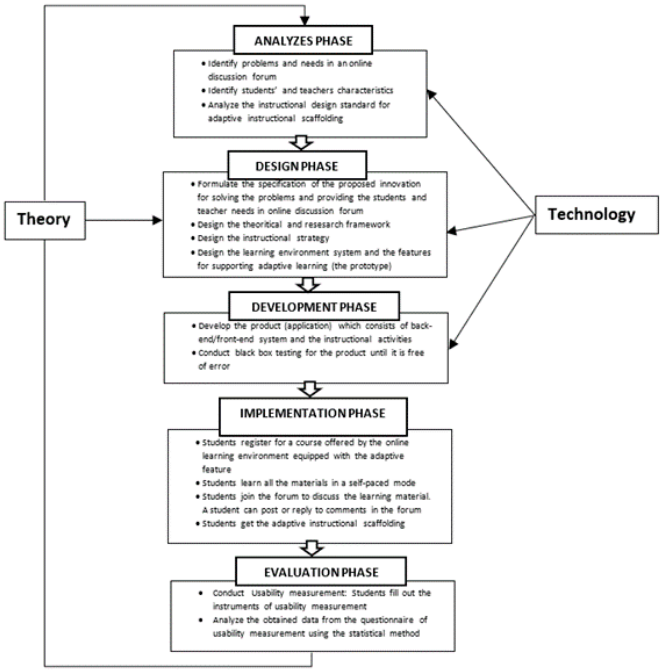


Table 1.
List of Question Items

	Usefulness (U):
Q1	The recommendation feature helps me be more effective in learning.
Q2	The recommendation feature helps me be more productive in learning.
Q3	I think the recommendation feature is useful.
Q4	The recommendation feature gives me more control over the activities in my learning.
Q5	The recommendation feature makes the things I want to accomplish easier to get done.
Q6	The recommendation feature saves me time when I use it.
Q7	The recommendation feature meets my needs (adaptive instructional scaffolding in the online forum).
Q8	The recommended article mostly relates to the topic that I discussed in the online forum.
Q9	The recommendation feature does everything I would expect it to do.
	Ease of Use (EoU):
Q10	The recommendation feature is easy to use.
Q11	The recommendation feature is simple to use.
Q12	The recommendation feature is user friendly.
Q13	The recommendation feature requires the fewest steps possible to accomplish what I want to do with it.
Q14	The recommendation feature is flexible.
Q15	Using the recommendation feature is effortless.
Q16	I can use the recommendation feature without written instructions.
Q17	I don't notice any inconsistencies as I use the recommendation feature.
Q18	Both occasional and regular users would like the recommendation feature.
Q19	When using the recommendation feature, I can recover from mistakes quickly and easily.
Q20	I can use the recommendation feature successfully every time.
	Ease of Learning (EoL)
Q21	I learned to use the recommendation feature quickly.
Q22	I easily remember how to use the recommendation feature.
Q23	It is easy to learn to use the recommendation feature.
Q24	I quickly became skillful with this recommendation feature.
	Satisfactions (S):
Q25	I am satisfied with this recommendation feature.
Q26	I am satisfied with the result of the recommended articles. (The articles were mostly related to the topic that I discussed in the online discussion forum.)
Q27	I would recommend it to a friend.
Q28	It is fun to use.
Q29	It works the way I want it to work.
Q30	It is wonderful.
Q31	I feel I need to have it in learning.
Q32	It is pleasant to use.

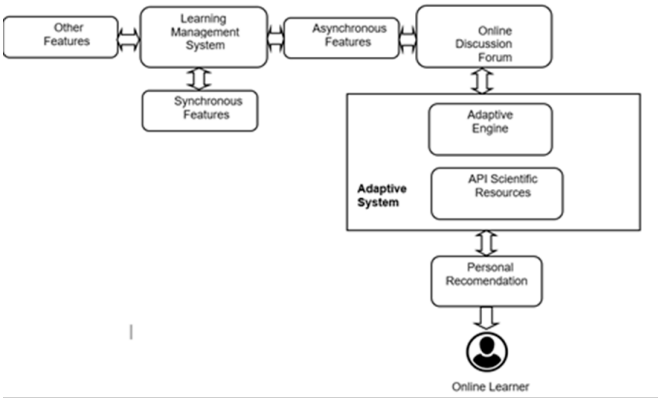
learning. Adaptive learning refers to a type of instructional method where students are given customized learning resources and activities to address their learning needs. It provides a personalized learning process according to students' needs (Wang et al., 2023). When an instructor uses adaptive instruction, they design the instructional plans and adjust their instructional modes to cope with the diverse needs of individual students (Ling & Chiang, 2022).

There are eight strategies that can help overcome problems that occur in online education forums related to teacher behavior: (a) Log in daily on the forum, (b) Monitor student situations, (c) Be objective, (d) Check how students access courses, (e) Categorize messages, (f) Provide feedback, (g) Encourage interaction, and (h) Create a friendly environment. These strategies are very difficult to apply when the learning takes place in a MOOC platform, where the number of students in a course is large (Liebowitz, 2011) and it is especially difficult to provide feedback to individual students.

This research work was designed to support students with suitable learning materials by providing feedback. Figure 2 depicts an adaptive instructional scaffolding framework in a MOOC learning environment. The LMS organizes several features, but we focused on asynchronous features, namely the online discussion forum.

The provided feedback is in the form of personal recommendations for reading articles that are generated based on comments in an online discussion forum. The recommended articles are to be generated in real time. Specifically, the adaptive engine module (see Figure 2) uses the students'

Figure 2.
Adaptive Instructional Scaffolding Framework



comments to generate the keywords. By using the Scopus API, these keywords are used to search for articles in the Scopus library.

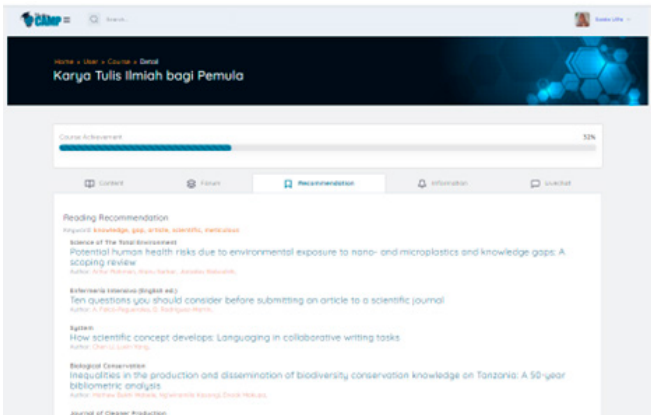
Adaptive instructional scaffolding interface in a MOOC environment

Figure 3 is a snapshot of the discussion forum on the MOOCs platform. Basically, the system consists of two important menus, the Forum and Recommendations. All the menus are located in the menu bar. The students can click the Forum menu and then start to participate in the discussion forum. There are several features provided in the online discussion forum, such as creating new discussion topics, replying to other posts, deleting posts, liking posts, and unliking posts.

Figure 3.
Discussion Activities in the Forum

In general, adaptive elearning dynamically changes the instruction method, based on certain variables, to present e-content. Some researchers have shown the advantage of adaptive elearning in improving the process of students' acquisition of knowledge, quality of experiences, and development of their higher thinking skills (El-Sabagh, 2021). Furthermore, this study emphasized an adaptive instructional scaffolding that recommends articles for reading via the Scopus database based on student comments posted on online discussion forums (see Figure 3). The recommendations are categorized as instructional scaffolding because they include learning support provided by the system directly in real time to replace the teacher's role (see Figure 4). Recommendations in the form of immediate feedback can be given to each student, so that through this strategy a more individualized learning experience can be created (Alrawashdeh, 2022).

Figure 4.
List of Recommendation Articles



Research conducted by Ross et al. (2018) indicated that adaptive assessment and providing immediate feedback for students contribute to enhancing student learning outcomes and fostering student motivation and engagement. Furthermore, research conducted by Awais Hassan et al. (2019) reiterated that the adaptive feedback system can improve student performance. This confirms that both the adaptive feedback system and the adaptive assessment accompanied by immediate feedback contribute significantly to learning performance.

Implementation and Evaluation of Online Adaptive Instructional Scaffolding in Online Discussion Forums

In developing an online learning system, usability measurement is one of the steps that must be performed so that the results of these measurements meet the student's needs and guarantee the quality of the particular elearning system. Thus, this measurement can give an idea of whether the system is usable and suitable for use (Hariyanto et al., 2020).

This research involved 137 participants who were students at a public university in Indonesia and responded to a questionnaire they were sent. The results of the questionnaire can be seen in Table 2, which shows the mean value range from 3.927 to 4.445 based on a 5-point Likert scale. While the SD value is in the range of 0.706 to 0.85, the data deviation with the average data tends to be small.

We concluded that this adaptive instructional scaffolding feature can be accepted by students.

Table 2.
Statistical Description

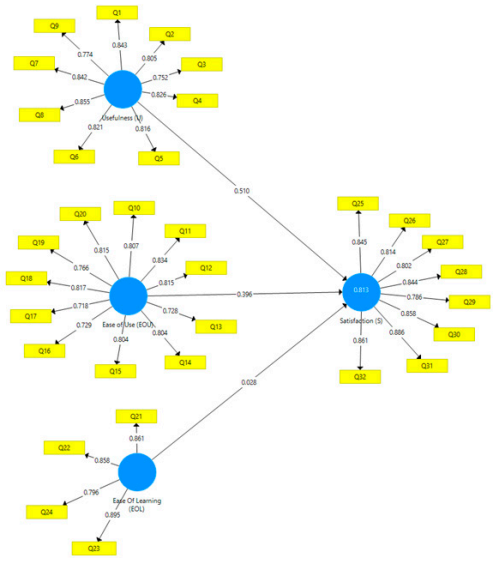
Q-Items	Mean	Median	Min	Max	Standard Deviation
Q1	4.19	4	1	5	0.72
Q2	4.124	4	1	5	0.778
Q3	4.445	5	1	5	0.744
Q4	4.175	4	1	5	0.845
Q5	4.117	4	1	5	0.829
Q6	4.146	4	1	5	0.779
Q7	4.131	4	1	5	0.753
Q8	4.088	4	1	5	0.769
Q9	3.993	4	1	5	0.833
Q10	4.416	5	1	5	0.761
Q11	4.445	5	1	5	0.792
Q12	4.365	5	1	5	0.763
Q13	4.073	4	1	5	0.761
Q14	4.299	4	1	5	0.823
Q15	4.226	4	1	5	0.745
Q16	4.007	4	1	5	0.85
Q17	3.927	4	1	5	0.834
Q18	4.08	4	1	5	0.745
Q19	4.058	4	1	5	0.799
Q20	4.124	4	1	5	0.806
Q21	4.27	4	1	5	0.769
Q22	4.285	4	2	5	0.714
Q23	4.328	4	1	5	0.706
Q24	4.058	4	1	5	0.771
Q25	4.095	4	1	5	0.763
Q26	4.044	4	1	5	0.772
Q27	4.102	4	1	5	0.822
Q28	4.044	4	1	5	0.818
Q29	4.022	4	1	5	0.74
Q30	4.153	4	1	5	0.818
Q31	4.175	4	1	5	0.734
Q32	4.161	4	1	5	0.747

To see the relationship between variables, an analysis of the structural equation model was carried out using SmartPLS 3. There were two assessments carried out to analyze the relationship between these variables, namely the assessment of the measurement model and the evaluation of the structural model. PLS-SEM structural model evaluation focuses on determining the significance and relevance of path coefficients (Hair et al., 2021).

Figure 5 is a visualization model of the relationship between Usefulness, Ease of Use, and Ease of Learning variables on Satisfaction. Based on Figure 5, the criteria for the measurement model are satisfied because all factor loadings on their relative construct exceed 0.70, all average variance extracted (AVE) values range from 0.618 to 0.728 (AVE > 0.50), and the composite reliability (CR) value ranges from 0.914 to 0.949, so we concluded that all research variables have good convergent validity (Fornell & Larcker, 1981). Cronbach Alpha (CA) values range from 0.875 to 0.939. According to Hair (2009), this value was acceptable for exploratory research.

Furthermore, the parameters measured to evaluate the structural model are the value of R squared (R^2) or determinant coefficient, normal fit index (NFI), path coefficient value, *t*-statistics, and *p*-values for the proposed model. Figure 5 has an R2 value of 80.9%. This means that 80.9% of the diversity of performance can be explained by the variables of Usefulness, Ease of Use, Ease of Learning, and Satisfaction. The remaining 19.1% is explained by other variables not measured in this study. The fit model value for NFI is 0.770.

Figure 5.
Relationship of the Variables Usefulness (U), Ease of Use (EoU), Ease of Learning (EoL), and Satisfaction (S)



The bootstrapping procedure was carried out to determine the relationship between latent variables. The criterion used was that a relationship is significant if the *t*-statistic value is > 1.96 and the *p*-value is < 0.05 at the 5% significance level. The direction of the relationship between variables can be seen from the positive or negative parameter coefficients. The results of path coefficient testing can be seen in Table 3.

Table 3.
Path Coefficient

Path	Path Coefficient	T-Statistics	P Values
Usefulness → Satisfaction	0.510	5.510	0.000
Ease of Uses → Satisfaction	0.396	4.253	0.000
Ease of Learnings → Satisfaction	0.028	0.328	0.743

The results of this study indicate that Usefulness has a significant positive effect on Satisfaction, as indicated by the *t*-statistics value of 0.510 and the *p*-value of 0.000. Likewise, the variable Ease of Use has a positive and significant effect on Satisfaction with a *t*-statistics value of 4.253 and a *p*-value of 0.000. The variable Ease of Learning has a positive but not significant effect on Satisfaction, as the *t*-statistics value is 0.328 and the *p*-value is 0.743. However, in general, this study is in line with research conducted by Lund (2001), which confirmed that each variable drives user satisfaction and frequency of use. Besides that, Hariyanto et al. (2020) also concluded that usefulness and ease of use have a positive and significant effect on satisfaction. Similar to the results of this study, Hariayanto et al. (2020) confirmed that ease of learning has a positive but nonsignificant effect on satisfaction because ease of learning only focuses on the level of effort on how to learn the system, while ease of use focuses on the ease of use for using the system.

In the realm of online learning environments, student satisfaction is an important variable that is widely acknowledged as a parameter of the success of elearning systems (Alqahtani et al., 2022; Ching & Maarof, 2021). In fact, in the research conducted by Forster et al. (2020), they mentioned that user satisfaction is known as an imperative variable for assessing the success of an information system. In measuring the usability of the system in this study, several examples of variables in the satisfaction dimension, such as Q27 ("I would recommend it to a friend") and Q31 ("I feel I need to have it in learning"), indicate student satisfaction will have implications on how this system will be used in the future. Based on the findings of this study (see Table 2), the participants gave a good response and the mean value of the two variables of Satisfaction and Usefulness is more than 4.00. Previous research has confirmed that student satisfaction was found to have a significant positive effect on student intention to utilize elearning (Hassanzadeh et al., 2012; Petter et al., 2008).

The usefulness dimension is an important predictor that influences satisfaction and also affects continuance attention (Daneji et al., 2019). These findings are in accordance with the work of Mtebe and Raphael (2018) and Tawafak et al. (2018), where they confirm the dimensions of how the usefulness of the elearning system affects the students' satisfaction. Perceived ease of use and students' satisfaction toward the adaptive elearning system has been reported to increase student satisfaction and engagement in learning, as well as students' need for online learning services that accord to their preferences (Baki et al., 2018; Daneji et al., 2019; Safsouf et al., 2020; Sunkara & Kurra, 2017; Tawafak et al., 2018).

The findings in this study also imply that teachers need to pay attention to the development of an elearning system that can facilitate an effective discussion space by providing support for instructional scaffolding features. This has an impact on increasing the efficiency of students in finding learning resources that are relevant to their curiosity in exploring the material they need. In addition, an adaptive automation and feedback system needs to be developed to increase engagement, motivation, satisfaction, and usability of the learning system. Furthermore, the availability of comprehensive learning resources with guaranteed content validity needs to be continuously improved and made available in the system, and it is necessary to measure the long-term impact on improving student learning outcomes.

CONCLUSION

In online learning based on MOOCs (Massive Open Online Courses), discussion forums are one of the asynchronous learning tools provided so that students can discuss matters related to the learning material. The number of comments in a forum is likely to be very large, especially when the forum is in a MOOC with a great number of online students where the teacher may find it difficult to respond individually. Therefore, there is a need for a feature that can assist teachers in providing immediate feedback to students. Our research resulted in producing an adaptive instructional scaffolding feature for online discussion forums on the MOOCs platform. The scaffolding is provided in the form of recommendations to students for reading articles sourced from the Scopus database, which creates a more individualized learning experience.

Usability measurement was carried out in this study to evaluate the features of adaptive instructional scaffolding using the USE questionnaire (usefulness, satisfaction, and ease of use) utilizing a 5-point Likert scale. In general, based on the results of descriptive statistical analysis gives an average mean above 4.00 so that the average response from students as research participants was *strongly agree* and *agree*. To measure the relationship between the usefulness, ease of use, and ease of learning variables on satisfaction, we carried out a structural equation model analysis using two tests: the assessment of the measurement model and the evaluation of the structural model. The results of the assessment of the measurement model show that the data used is valid for testing the structural model assessment. The structural model assessment test focuses on evaluating the significance and relevance of the path coefficients of the proposed model, and the results of this measurement can be categorized as valid.

These research findings revealed that the adaptive scaffolding system appeals to students and the usefulness dimension has a significant positive effect on satisfaction. This usefulness dimension provides an illustration of how students believe in the adaptive instructional scaffolding feature, which helps them positively improve their learning performance, with this belief having an impact on satisfaction. As with the dimension of ease of use, the results of this study show that this dimension has a positive and significant effect on satisfaction. This shows that students believe that the use of the adaptive instructional scaffolding feature is effortless and easy to use, and thus it has an impact on their satisfaction. However, it is slightly different from the use of learning dimension (which is part of the ease of use dimension) and the effect on satisfaction is not significant. This is because ease of use measures how students learn to use this feature. Because this feature has been designed to be easy to use, students no longer need to make learning efforts using this system.

The results of this study show how adaptive instructional scaffolding in an online discussion forum thoroughly helps students get immediate feedback, which is difficult for them to get when they rely on the teacher. In the future, this feature can be widely implemented in MOOCs platforms that have a large number of students. This research is a pilot project, and there are still many things that need to be investigated in the future, including how measuring the effects of adaptive instructional scaffolding in online discussion forums can directly improve student learning performance.

Conflict-of-Interest Statement

The study was carried out without any commercial or financial ties that could be viewed as a potential conflict of interest.

References

Ak, Ş. (2016). The role of technology-based scaffolding in problem-based online asynchronous discussion. British Journal of Educational Technology, 47(4), 680–693. https://doi.org/10.1111/bjet.12254

Aldoobie, N. (2015). ADDIE model. American International Journal of Contemporary Research, 5(6), 68–72. https://www.aijcrnet.com/journals/Vol_5_No_6_December_2015/10.pdf

Aloni, M., & Harrington, C. (2018). Research based practices for improving the effectiveness of asynchronous online discussion boards. Scholarship of Teaching and Learning in Psychology, 4(4), 271–289. https://doi.org/10.1037/stl0000121

Alqahtani, M. A., Alamri, M. M., Sayaf, A. M., & Al-Rahmi, W. M. (2022). Exploring student satisfaction and acceptance of e-learning technologies in Saudi higher education. Frontiers in Psychology, 13, 939336. https://doi.org/10.3389/fpsyg.2022.939336

Alrawashdeh, G. S. (2022). Approaches to technology-enabled personalized and adaptive learning: A brief overview. OSFPreprints. https://doi.org/10.31219/osf.io/98u7r

Aroyo, L., Dolog, P., Houben, G.-J., Kravcik, M., Naeve, A., Nilsson, M., & Wild, F. (2006). Interoperability in personalized adaptive learning. Journal of Educational Technology & Society, 9(2), 4–18.

Awais Hassan, M., Habiba, U., Khalid, H., Shoaib, M., & Arshad, S. (2019). An adaptive feedback system to improve student performance based on collaborative behavior. In IEEE Access: Practical Innovations, Open Solutions (vol. 7, pp. 107171–107178). IEEE. https://doi.org/10.1109/ACCESS.2019.2931565

Baguley, M., Danaher, P. A., Davies, A., George-Walker, L., Jones, J. K., Matthews, K. J., Midgley, W., & Arden, C. H. (2014). Educational learning and development: building and enhancing capacity. Springer. https://doi.org/10.1057/9781137392848

Baki, R., Birgoren, B., & Aktepe, A. (2018). A meta-analysis of factors affecting perceived usefulness and perceived ease of use in the adoption of e-learning systems. Turkish Online Journal of Distance Education, 19(4), 4–42. https://doi.org/10.17718/tojde.471649

Belland, B. R. (2014). Scaffolding: Definition, current debates, and future directions. In J. Spector, M. Merrill, J. Elen, & M. Bishop (Eds.), Handbook of research on educational communications and technology (pp. 505–518). Springer. https://doi.org/10.1007/978-1-4614-3185-5_39

Belland, B. R. (2017). Instructional scaffolding: Foundations and evolving definition. In Instructional scaffolding in STEM education (pp. 17–53). Springer. https://doi.org/10.1007/978-3-319-02565-0_2

Belland, B. R., Kim, C., & Hannafin, M. J. (2013). A framework for designing scaffolds that improve motivation and cognition. Educational Psychologist, 48(4), 243–270. https://doi.org/10.1080/00461520.2013.838920

Belland, B. R., Walker, A. E., Kim, N. J., & Lefler, M. (2017a). Synthesizing results from empirical research on computer-based scaffolding in STEM education: A meta-analysis. Review of Educational Research, 87(2), 309–344. https://doi.org/10.3102/0034654316670999

Belland, B. R., Walker, A. E., & Kim, N. J. (2017b). A Bayesian network meta-analysis to synthesize the influence of contexts of scaffolding use on cognitive outcomes in STEM education. Review of Educational Research, 87(6), 1042–1081. https://doi.org/10.3102/0034654317723009

Bhattacharya, S., & Roy, S. (2011). Intelligent scaffolding system based on fuzzy agent for an e-learning environment. In Proceedings of the Fifth Indian International Conference on Artificial Intelligence, IICAI 2011, Tumkur, Karnataka State, India, December 14–16, 2011 (pp. 1519–1531).

Branch, R. M. (2009). Instructional design: The ADDIE approach. Springer Science & Business Media. https://doi.org/10.1007/978-0-387-09506-6

Brika, S. K. M., Chergui, K., Algamdi, A., Musa, A. A., & Zouaghi, R. (2022). E-learning research trends in higher education in light of COVID-19: A bibliometric analysis. Frontiers in Psychology, 12, 762819. https://doi.org/10.3389/fpsyg.2021.762819

Cerezo, R., Sánchez-Santillán, M., Paule-Ruiz, M. P., & Núñez, J. C. (2016). Students' LMS interaction patterns and their relationship with achievement: A case study in higher education. Computers & Education, 96, 42–54. https://doi.org/10.1016/j.compedu.2016.02.006

Ching, C. W., & Maarof, N. (2021). Effect of student satisfaction on elearning quality and learning outcome among Malaysian undergraduate nursing students. Journal of Educators Online, 18(3). https://doi.org/10.9743/JEO.2021.18.3.2

Choo, S. S. Y., Rotgans, J. I., Yew, E. H. J., & Schmidt, H. G. (2011). Effect of worksheet scaffolds on student learning in problem-based learning. Advances in Health Sciences Education, 16, 517–528. https://doi.org/10.1007/s10459-011-9288-1

Cronbach, L. J. (1957). The two disciplines of scientific psychology. American Psychologist, 12(11), 671–684. https://doi.org/10.1037/h0043943

Daneji, A. A., Ayub, A. F. M., & Khambari, M. N. M. (2019). The effects of perceived usefulness, confirmation and satisfaction on continuance intention in using massive open online course (MOOC). Knowledge Management & E-Learning, 11(2), 201–214. https://doi.org/10.34105/j.kmel.2019.11.010

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13, 319–340. https://doi.org/10.2307/249008

de Lima, D. P. R., Gerosa, M. A., Conte, T. U., & de M. Netto, J. F. (2019). What to expect, and how to improve online discussion forums: The instructors' perspective. Journal of Internet Services and Applications, 10, 22. https://doi.org/10.1186/s13174-019-0120-0

Delahunty, J., Jones, P., & Verenikina, I. (2014). Movers and shapers: Teaching in online environments. Linguistics and Education, 28, 54–78. https://doi.org/10.1016/j.linged.2014.08.004

Delahunty, J., Verenikina, I., & Jones, P. (2014). Socio-emotional connections: Identity, belonging and learning in online interactions. A literature review. Technology, Pedagogy and Education, 23(2), 243–265. https://doi.org/10.1080/1475939X.2013.813405

Devedžić, V. (2006). Semantic web and education (Vol. 12). Springer Science & Business Media.

El-Sabagh, H. A. (2021). Adaptive e-learning environment based on learning styles and its impact on development students' engagement. International Journal of Educational Technology in Higher Education, 18(1), 53. https://doi.org/10.1186/s41239-021-00289-4

Fornell, C., & Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics. Journal of Marketing Research, 18(3), 382–388. https://doi.org/10.1177/002224378101800313

Forster, Y., Hergeth, S., Naujoks, F., Krems, J. F., & Keinath, A. (2020). What and how to tell beforehand: The effect of user education on understanding, interaction and satisfaction with driving automation. Transportation Research Part F: Traffic Psychology and Behaviour, 68, 316–335. https://doi.org/10.1016/j.trf.2019.11.017

Gardner, H. (1987). The theory of multiple intelligences. Annals of Dyslexia, 19–35. https://doi.org/10.1007/BF02648057

Goller, M., & Paloniemi, S. (2017). Agency at work, learning and professional development: An introduction. In M. Goller & S. Paloniemi (Eds.), Agency at work (pp. 1–14). Springer. https://doi.org/10.1007/978-3-319-60943-0_1

Gynther, K. (2016). Design framework for an adaptive MOOC Enhanced by blended learning: Supplementary training and personalized learning for teacher professional development. Electronic Journal of e-Learning, 14(1), 15–30. https://files.eric.ed.gov/fulltext/EJ1099385.pdf

Hair, J. F. (2009). Multivariate data analysis (6th ed.). Pearson.

Hair, J. F., Jr., Hult, G. T. M., Ringle, C. M., Sarstedt, M., Danks, N. P., Ray, S., ... & Ray, S. (2021). Evaluation of the structural model. In Partial least squares structural equation modeling (PLS-SEM) using R: A workbook (pp. 115–138). Springer. https://doi.org/10.1007/978-3-030-80519-7_6

Hariyanto, D., Triyono, M., & Köhler, T. (2020). Usability evaluation of personalized adaptive e-learning system using use questionnaire. Knowledge Management & E-Learning, 12(1), 85–105. https://doi.org/10.34105/j.kmel.2020.12.005

Hassanzadeh, A., Kanaani, F., & Elahi, S. (2012). A model for measuring e-learning systems success in universities. Expert Systems with Applications, 39(12), 10959–10966. https://doi.org/10.1016/j.eswa.2012.03.028

Hull, D. M., & Saxon, T. F. (2009). Negotiation of meaning and co-construction of knowledge: An experimental analysis of asynchronous online instruction. Computers & Education, 52(3), 624–639. https://doi.org/10.1016/j.compedu.2008.11.005

Kim, N. J., Belland, B. R., & Walker, A. E. (2018). Effectiveness of computer-based scaffolding in the context of problem-based learning for STEM education: Bayesian meta-analysis. Educational Psychology Review, 30(2), 397–429. https://doi.org/10.1007/s10648-017-9419-1

Kinshuk. (2016). Designing adaptive and personalized learning environments. Routledge.

Klašnja-Milićević, A., Vesin, B., Ivanović, M., Budimac, Z., & Jain, L. C. (2016). E-learning systems: Intelligent techniques for personalization). Springer.

Liebowitz, J. (2011). Commentary–The university LIMO (Learning in Mobile Organisations): Riding in style. International Journal of Mobile Learning and Organisation, 5(3/4), 207–210. https://doi.org/10.1504/IJMLO.2011.045323

Ling, H.-C., & Chiang, H.-S. (2022). Learning performance in adaptive learning systems: A case study of web programming learning recommendations. Frontiers in Psychology, 13, 770637. https://doi.org/10.3389/fpsyg.2022.770637

Liu, L., Wu, W., & Huang, J. (2018). SARLR: Self-adaptive recommendation of learning resources. In N. Guin & A. N. Kumar (Eds.), Proceedings of the 14th International Conference on Intelligent Tutoring Systems 2018 Workshops (pp. 151–158). https://ceur-ws.org/Vol-2354/w4paper4.pdf

Lund, A. M. (2001). Measuring usability with the use questionnaire12. Usability Interface, 8(2), 3–6.

Mercer, N., & Howe, C. (2012). Explaining the dialogic processes of teaching and learning: The value and potential of sociocultural theory. Learning, Culture and Social Interaction, 1(1), 12–21. https://doi.org/10.1016/j.lcsi.2012.03.001

Mtebe, J. S., & Raphael, C. (2018). Key factors in learners' satisfaction with the e-learning system at the University of Dar es Salaam, Tanzania. Australasian Journal of Educational Technology, 34(4). https://doi.org/10.14742/ajet.2993

Onah, D. F. O., Sinclair, J. E., & Boyatt, R. (2014). Exploring the use of MOOC discussion forums. In Proceedings of London International Conference on Education (pp. 1–4). LICE.

Onyema, E. M., Deborah, E. C., Alsayed, A. O., Naveed, Q. N., & Sanober, S. (2019). Online discussion forum as a tool for interactive learning and communication. International Journal of Recent Technology and Engineering, 8(4), 4852–4859. https://doi.org/10.35940/ijrte.D8062.118419

Pérez-Sanagustín, M., Sapunar-Opazo, D., Pérez-Álvarez, R., Hilliger, I., Bey, A., Maldonado-Mahauad, J., & Baier, J. (2021). A MOOC-based flipped experience: Scaffolding SRL strategies improves learners' time management and engagement. Computer Applications in Engineering Education, 29(4), 750–768. https://doi.org/10.1002/cae.22337

Petter, S., DeLone, W., & McLean, E. (2008). Measuring information systems success: Models, dimensions, measures, and interrelationships. European Journal of Information Systems, 17(3), 236–263. https://doi.org/10.1057/ejis.2008.15

Ross, B., Chase, A.-M., Robbie, D., Oates, G., & Absalom, Y. (2018). Adaptive quizzes to increase motivation, engagement and learning outcomes in a first year accounting unit. International Journal of Educational Technology in Higher Education, 15(1), 30. https://doi.org/10.1186/s41239-018-0113-2

Safsouf, Y., Mansouri, K., & Poirier, F. (2020). Smart learning environment, measure online student satisfaction: A case study in the context of higher education in Morocco. In 2020 International Conference on Electrical and Information Technologies (ICEIT) (pp. 1–5). IEEE. https://doi.org/10.1109/ICEIT48248.2020.9113189

Schmidt, H. G., Rotgans, J. I., & Yew, E. H. (2011). The process of problem-based learning: What works and why. Medical Education, 45(8), 792–806. https://doi.org/10.1111/j.1365-2923.2011.04035.x

Schmidt, H. G., Rotgans, J. I., & Yew, E. H. J. (2019). Cognitive constructivist foundations of problem-based learning. In M. Moallem, W. Hung, & N. Dabbagh (Eds.), The Wiley handbook of problem-based learning (pp. 25–50). Wiley. https://doi.org/10.1002/9781119173243.ch2

Shen, Y., Huang, L., & Wu, X. (2022). Visualization analysis on the research topic and hotspot of online learning by using CiteSpace—Based on the Web of Science core collection (2004–2022). Frontiers in Psychology, 13, 1059858. https://doi.org/10.3389/fpsyg.2022.1059858

Sunkara, V. M., & Kurra, R. R. (2017). An analysis of learner satisfaction and needs on e-learning systems. International Journal of Computational Intelligence Research, 13(3), 433–444.

Szabo, Z., & Schwartz, J. (2011). Learning methods for teacher education: The use of online discussions to improve critical thinking. Technology, Pedagogy and Education, 20(1), 79–94. https://doi.org/10.1080/1475939X.2010.534866

Tang, Q. (2016). A personalised learning service for MOOCs. World Transactions on Engineering and Technology Education, 14(1), 140–145.

Tawafak, R. M., Romli, A. B., & Arshah, R. B. A. (2018). Continued intention to use UCOM: Four factors for integrating with a technology acceptance model to moderate the satisfaction of learning. In IEEE Access (vol. 6, pp. 66481–66498). IEEE. https://doi.org/10.1109/ACCESS.2018.2877760

van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in teacher-student interaction: A decade of research. Educational Psychology Review, 22(3), 271–296. https://doi.org/10.1007/s10648-010-9127-6

Verenikina, I. (2008). Scaffolding and learning: Its role in nurturing new learners. In P. Kell, W. Vialle, D. Konza, & G. Vogl (Eds.), Learning and the learner: Exploring learning for new times. University of Wollongong. https://ro.uow.edu.au/edupapers/43/

Verenikina, I., Jones, P., & Delahunty, J. (2019). Building capacity to scaffold online discussion: Enhancing students' construction of knowledge and communication competencies (Final report). Australian Government. Department of Education and Training. https://ltr.edu.au/resources/zzSD15-5131-FinalReport-Buildingcapacity-Verenkikina_2019.pdf

Wang, S., Christensen, C., Cui, W., Tong, R., Yarnall, L., Shear, L., & Feng, M. (2023). When adaptive learning is effective learning: Comparison of an adaptive learning system to teacher-led instruction. Interactive Learning Environment, 31(2), 793–803. https://doi.org/10.1080/10494820.2020.1808794

Wang, Q., & Woo, H. L. (2007). Comparing asynchronous online discussions and face-to-face discussions in a classroom setting. British Journal of Educational Technology, 38(2), 272–286. https://doi.org/10.1111/j.1467-8535.2006.00621.x

Wise, A. F., Cui, Y., & Vytasek, J. (2016). Bringing order to chaos in MOOC discussion forums with content-related thread identification. In LAK 16: Proceedings of the Sixth International Conference on Learning Analytics & Knowledge (pp. 188–197). Association for Computing Machinery. https://doi.org/10.1145/2883851.2883916

Yeh, Y.-C. (2010). Analyzing online behaviors, roles, and learning communities via online discussions. Journal of Educational Technology & Society, 13(1), 140–151. https://www.jstor.org/stable/jeductechsoci.13.1.140

Zhu, Z.-T., Yu, M.-H., & Riezebos, P. (2016). A research framework of smart education. Smart Learning Environments, 3, 4. https://doi.org/10.1186/s40561-016-0026-2