Using E-Scaffolding for Developing STEM Students' Questioning Skills and Learning Engagement

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Abstract

The purpose of the study was to investigate the impact of using E-Scaffolding for developing Faculty of Education STEM students' questioning skills and learning engagement. The researchers co- taught "English *for STEM 1*" in the first term of the academic year2022-2023. The present study adopted the pre-experimental research design. Thirty nine students were enrolled at the first year in STEM program; (16) were specialized in Chemistry and (23) others were specialized in Mathematics. They participated in the study and acted as one study group. To achieve the objectives of the study, the researchers designed a questioning skills test and a learning engagement scale. The researchers developed a teacher's guide adopting E-Scaffolding. Students received twelve sessions; one hour a week with an online extension. The findings showed a considerable statistical improvement favoring the post testing of the questioning skills test and the post administration of the learning engagement scale.

Keywords: *E- Scaffolding – Questioning Skills- Learning Engagement*

Introduction

Asking questions is one of the essential human habits. Being a strong communicator requires many skills including how to ask questions effectively. Asking questions is very crucial in gathering information. By asking the right questions one can learn about a new task, better understand a learning situation, determine hypothetical answers to questions and solve problems. Questions may be asked by students as well as teachers; they are essential tools for both teaching and learning.

The ability to ask questions is a thought process related to critical thinking, creative thinking and problem solving (Chin & Osborne 2008). Questioning skills are essential because they are closely related to the curiosity that identifies a phenomenon or a question. Especially science emphasizes curiosity, so questioning skill is an important component because it is included in the scientific method and in the scientific attitude. Therefore, asking questions happens because there is a gap between students' knowledge their information. (Cautinho & Almeida, 2014).

Questioning skills generally aim to guide students to structure their knowledge, understand scientific content conceptually, develop relevant process skills and understand the nature of science. (Chin & Chia, 2006; Ekici, 2017; Zion & Sadeh, 2007). The questioning skill is defined as a basic skill by Ministry of National Education (2007) which involves noticing and understanding the problem by asking the correct and meaningful questions, planning research on what to solve and how to solve the problem, estimating and testing the results and developing ideas.

Science is the process of asking questions and finding answers to that query. Therefore, students and teachers need to actively participate in the questioning process. Therefore, pre-service STEM (Science, Technology, Engineering and Mathematics) teachers need to be equipped with an array of questioning skills. STEM is a curriculum based on the idea of educating students in four specific disciplines – science, technology, engineering and mathematics. STEM education is considered as one of the most remarkable educational movements in recent years. STEM education aims at the development of students' research questioning, logical reasoning, and working behaviors in collaboration. (Sen, , Ay and Kirary, 2020). It is a holistic approach that enables the development of the 21th century skills in individuals such as problem solving, leadership, media literacy and communication skills. (Cetin, 2021). .

In a classroom setting, a student centered teacher tries to create an environment which will motivate the students to discover new skills and knowledge. Teachers are no longer supposed to transfer facts into passive students' heads but rather facilitate their discovery of relevant information. (Musingafi and Muranda, 2014). Therefore, Teachers have to encourage students to ask questions in order to meaningfully construct knowledge. Teachers have to provide support to students engaging them in problem-centered instructional approaches.

In this concern, Bowker (2010) emphasizes that in the teaching and learning processes there are two types of questions, teacher generated questions and student generated questions. Teacher generated questions are questions that leave control of the learning process in the hands of the teacher and make students dependent upon the teacher. Student generated questions are generated by students and they give them control and ownership of the learning process and engage the course material as independent thinker. Therefore, to enable students to ask inquiry generated questions was what the researchers of the current study sought to achieve.

Scaffolding is a Vygotskyan concept that focuses on providing supportive aid from adults or experts to learners within the learning zone of proximal development. According to Dabbagh (2003), the zone of proximal development refers to the difference between the current knowledge and ability of learners and what they can accomplish with or without assistance when tackling a challenge. Scaffolding helps learners by gradually limiting complexities present in the learning context, and then removing those limits as the learners gain knowledge, confidence, and skills in tackling complex concepts.

Shin, Brush and Glazewski (2020) indicate that there are three types of scaffolding: hard, teacher , and peer scaffolding . Hard scaffolding is a static support that can be planned with learners who face potential difficulties in a given context. Inquiry based scaffolding students wildly use hard scaffolding. For example, hard scaffolding includes professional videos that offer problem-solving support through clues and samples in the form of text or video to aid in understanding. Teacher scaffolding is also known as institutional scaffolding, and it involves support from teachers throughout the learning process to enhance mastery of the tasks. Teachers use various strategies to achieve scaffolding functions in the zone of proximal development. For example, teachers provide resources, questions, prompts and expert advice to learners as well as learning tools and guides. Peer-scaffolding is the process which learners offer problem solving solutions to their peers when needed. Peer-scaffolding encourages group collaborative learning and enhances face-to-face interactions during discussions.

E- Scaffolding is a product of online learning aids (e-learning) using website and scaffolding facilities (Ayu et.al , 2017). Using e-scaffolding can help inspire students to partake in learning activities, which reinforce their desire to achieve learning goals as their achievement. E-scaffolding can increase the quality of process and learning outcomes.

Krzic, Wilson and Hoffman (2018) state that E- Scaffolding is a way to provide temporary support and direction to learners during the learning process to help them to complete new learning tasks and to encourage them to build knowledge by themselves. This is something that learners may not be able to do without this help.

Loparev (2016) clarifies that E-scaffolding may take the form of instructions, tips, and/or messages of help. It may involve asking questions and presenting additional examples related to an educational situation to ensure the continuity of the educational process, and to guide the learners towards mastering various areas of knowledge, ability, and skills to achieve their educational goals successfully.

Center for Innovative Teaching and Learning (2012) mentions some benefits of e-scaffolding:

- Challenges students through deep learning and discovery
- Engages students in meaningful and dynamic discussions in small and large classes
- Motivates learners to become better students (learning how to learn)
- Increases the likelihood for students to meet instructional objectives
- Provides individualized instruction (especially in smaller classrooms)
- Can be “recycled” for other learning situations
- Affords the opportunity for peer-teaching and learning
- Provides a welcoming and caring learning environment

In developing 21st-century skills, improvement of STEM education is in demand in most countries for solving complex global issues and global economic development. Effective questioning skills by STEM teachers could help to engage and scaffold students in learning and higher-level thinking process.(Nor'Aida Khairuddin, Harmeni, and Radzali, 2019)

Engagement is an essential educational component as it leads to many positive student outcomes such as academic learning, achievement, skill development, and academic resilience in different educational fields. (Reeve, 2012; Skinner et al., 2008) including the STEM educational field (Bathgate & Schunn, 2017). To maximize engagement, learning activities should be scaffolded over time and in a way that ensures students are making meaningful use of class time (Gomes and Paul , 2018).

To maximize students' engagement and better support them to complete cognitively challenging tasks , instructors need to scaffold their learning through gradual sequencing and structuring of both in-class and out –of-class learning activities and this happens with online learning where students have to view material at their own pace. This exactly what the researchers did in the experimentation .They posted links, You tube videos and pdf. files on the prescribed and the predetermined Google Classroom and What's App group to deliver and receive any materials, assignments, announcements and inquiries.

Literature review

A number of studies were conducted in the areas of using e-scaffolding , Questioning skills ,learning engagement in general and more specifically in STEM Education . For example Setaninggrum, Mulyono and Rosyida (2022) conducted a study to describe the ability to solve mathematical problems in terms of independent learning of students in learning Problem Based Learning with e-scaffolding. They used a qualitative method with Thirty six research subjects at SMA in the 2021/2022 academic year. The instruments included an independent learning questionnaire, test of problem solving abilities and interviews. Data were analyzed descriptively through data reduction, data display, and triangulation. The results of the study showed that (1) students with high learning independence have high and moderate mathematical problem-solving abilities; (2) students with moderate learning independence have high, medium, and low problem-solving abilities; (3) students with low learning independence have moderate and low mathematical problem solving abilities. Consequently, the results emphasized the role of e-scaffolding in enhancing the learning process.

Another study was conducted by Amelia, Rofiki, Tortop and Abah (2020) to examine the effect of e-scaffolding in blended learning on pre-service teachers' scientific explanation abilities as well as to find out the patterns of scientific explanation of pre-service teachers who learn by e-scaffolding in blended learning. The study employed mixed-method with concurrent embedded design. Quasi-experimental research design in the form of a one-group pretest-posttest control group design was used as a quantitative approach, whereas the learning process and scientific explanation patterns were described in a qualitative approach. The population of this study was 152 elementary school pre-service teachers of a state university at Malang, while the sample was 24 elementary school pre-service teachers in the seventh semester. The instrument used for measuring scientific explanation abilities was problem descriptions. The finding of the study indicated that pre-service teachers' scientific explanation improved after learning with e-scaffolding in blended learning. The pre-service teachers were able to explain the relationship between theory and problems very well.

Additionally, Koes, Suwasono and Pramono (2019) conducted a study to determine the impact of e-scaffolding on hybrid learning on the ability to solve physics problems. They used a mixed method research to two groups of freshman majoring in physics at the State University of Malang. The Experimental group that learned physics through e-scaffolding in hybrid learning consisted of 26 students, while the comparison group that learned through direct instruction consisted of 23 students. The research data were collected by giving the non-routine problems to both groups of students and analyzed using ANCOVA. The results showed that students who learned through e-scaffolding in hybrid learning could solve physics problems higher than that of students who learned through direct instruction.

Rajaram (2019) proposed an improved flipped classroom framework embedded with an e-scaffolding learning support system which can be adopted in 'real –time' during class. The proposed framework comprised pre-class online learning and face to face seminars, with the goal of helping students be more engaged in their learning. A post –course survey was carried out with 59 undergraduate business students, from which twelve were interviewed about their experience of this flipped classroom learning design and the e-scaffolding learning support system. The findings were positive.

Ayu, Jufriadi, Pratiwi and Sujito (2018) conducted a study to identify the effect of e-scaffolding on motivation and achievement of students. The study used quasi experimental design with post- test control group design the data analysis technique used was a one-way analysis of variance. Results revealed that e-scaffolding could help students to learn mathematical physics more effectively at their own pace and be flexible with their times. E-scaffolding led to improve motivation and achievement than traditional teaching.

Saman , Koes and Sunaryono (2018) aimed to design scaffolding that was connected to an ICT system (e-scaffolding) which was implemented with blended learning to improve students physics problem solving skills (PSS). The research method used is Borg and Gall research method and t- test was used .The study focused on procedural types of scaffolding using prompt questions and facts found during the implementation. Results showed e-scaffolding was appropriate to be used for several examinations after being evaluated by experts and practitioners. E-scaffolding was able to connect between students in solving problems both in synchronous and asynchronous collaboration. In addition, e-scaffolding was able to split problem categories and led to increase students' physics problem solving skills.

Belland , Walker, Oslen and Leary (2015) employed meta-analysis to determine the impact of computer-based scaffolding characteristics and study and test score quality on cognitive outcomes in science, technology, engineering, and mathematics education at the secondary, college, graduate, and adult levels. Results indicated that (a) computer-based scaffolding positively influences learning (g = 0.53), (b) studies with zero threats to internal validity had lower effect sizes than studies with two threats, (c) studies with one threat to external validity had higher effect sizes than studies with zero threats, (d) studies with no fading had higher effect sizes than studies with fixed fading, and (e) students performed better when using conceptual scaffolds than with metacognitive scaffolds. There were no differences based on study design, generic vs. specific, paired intervention, assessment level, or intended learning outcome. Meta-regression indicated that fading explained 30% of the variability in outcomes. The significance of this study lied in its potential to steer scaffold designers away from fixed fading and metacognitive scaffolds, and toward studying scaffolding in authentic contexts, rather than laboratories. Furthermore, this study indicated that a more comprehensive scaffolding meta-analysis is warranted.

Concerning the studies related to questioning skills, Cetin (2021) conducted a study with the aim of investigating the relationship between pre-service form, elementary mathematics and elementary science teacher's STEM awareness and questioning skills. In addition to this aim, whether differences existed or not was also investigated in terms of the gender, class level and department variables. A total of 195 pre-service teachers participated in the study from 3^{rd} and 4^{th} years in the academic year of 2019-2020. The STEM Awareness and Questioning Skills Scales were used in this correlation study. Non-parametric tests were used in data analysis. For the STEM awareness positive opinion dimension statistically significant differences were found in favor of the 4^{th} year participants. For the questioning Skills knowledge control dimension, a statistically significant difference was found according to the gender in favor of the male participants. A medium- level positive relationship was found between the STEM awareness positive opinion dimension and the questioning skills dimensions, while a low- level relationship was found between the negative opinions and the questioning skills dimensions.

Nurramadhani, Lathifah & Permana (2020) conducted a study to develop a STEM –based E-module to investigate the development of students' questions quality. The research method used was ADDIE (Analyze, Design, Develop, Implementation and Evaluation) .The instruments used to collect data were video transcription, application transcription, reading test, and questionnaire. The research was conducted on 26 university students who took Science Environmental Technology and Social (SETS) course. Questions' quality rubrics were used to analyze the data. As a result of this research, the implementation of developed STEM- based E- Modules was achievable. The main finding of this research was the question's quality from the lecturer might have some influence on the quality of the students' questions.

Nor'Aida Khairuddin, Harmeni, and Radzali, (2019) conducted meta-analysis to develop effective Hots questioning skills for STEM teachers in Malaysia. The researchers of the study conducted an overview of effective strategies to develop HOTs questioning skills. The research methodology was based on literature review search strategy through ERIC, online database and journals such as EBSCOhost, Science Direct, Scopus, Springer Link, Web of Science (WoS), SAGE, Taylor and Francis Online, and Wiley Online Library. The keywords used for this research were STEM education, questioning skills, higher-order thinking skills (HOTS) and STEM pedagogical development. From the meta-analysis, the results showed that promoting inquiry approach, proper wait-time, pedagogical content knowledge and recognition were the dominant strategies in questioning, which helped to develop students' cognitive and HOTS abilities. Findings from this review will guide the STEM teachers to enhance their pedagogical skills, especially in HOTS questioning and strengthen the quality of STEM education in future.

Dos, Bay, Aslansoy, Tiryaki, Cetin and Duman (2016) conducted a study for analyzing teacher's questioning strategies from various aspects. The participants of the study were 170 primary school teachers working in schools located in the center of Gaziantep province in Turkey. Data were collected through a semi-structured questionnaire and were examined via content analysis. Explanatory mixed design was used to analyze the research problem. Findings revealed that: (1) Teachers asked divergent questions to draw attention and interest. (2) Teachers had understanding of divergent and convergent questions (3) Teachers mostly asked questions to entire class than individuals (4) Teachers generally used probing questions, prolonged waiting time and did not ask vague questions (6) Teachers did not use questions as a punishment tool. This study revealed that asking good questions must be considered more important in pre-service education and teachers must be supported by in-service trainings to be more effective in asking questions.

Musingafi and Muranda (2014) propped a review of the role played by students generated questions in the teaching and learning process. They highlighted the value of students' questions in the learning-teaching process; reviewed the research on student-generated questions and suggested some strategies that teachers could use to foster a culture of inquisitiveness in their classrooms.

Regarding the development of students' learning engagement, Struyf, Loof, Boeve- de Pauw and Petegem (2019) explored how students' engagement varies in different STEM learning environments. More specifically, they focused on the significance of a learning environment applying an integrated STEM (iSTEM) approach and the significance of STEM learning environments' student- centeredness. They also explored the relative importance of different student-centered principles (lesson plan and implementation, communicative interactions, student-teacher relations) for students' engagement in the STEM learning environment. Using a mixed method approach, they drew from observational data of 24 STEM lessons in combination with data from seven focus groups with 67 grade and 9 students. Results revealed that i STEM is a good practice to engage students in the STEM learning environment, as it facilitates teachers' implementation of a general student approach.

Thibauat, Ceuppens, Loof, Meester, Goovaerts, Struf and Depaepe (2018) provided a well-defined framework for instructional practices in integrated STEM in secondary education, based on the results of a systematic review of existing literature. The framework contained five key principles: integration of STEM content, problem-centered learning, inquiry-based learning, design-based learning and cooperative learning. The proposed framework had several benefits, including its applicability in the classroom and the possibility to describe integrated STEM on multiple dimensions. Nonetheless, further research is necessary to investigate the effects of integrated STEM on students' cognitive and affective learning outcomes.

Hardijito (2010) conducted a study to identify the use of scaffolding approach to enhance students' engagement in learning structural analysis with civil engineering students. In this approach, students were provided with a series of practice problems, each one comes with the steps, formulas, hints, and tables needed to solve the problem. Gradually, with the growing confidence to apply the method as a tool to analyze structures, the amount of help provided was reduced, until finally no help was provided at all. The study concluded that through scaffolding students' engagement was greatly enhanced as they were much involved in the learning process.

Commentary

The above mentioned review of related studies concerning e-scaffolding, STEM Education, questioning skills and learning engagement gave the researchers enough knowledge and confidence to state the hypotheses of the study. It also revealed that most studies related to e-scaffolding, questioning skills and learning engagement were conducted out of the Egyptian context. Therefore, the current study sought to fill this gap. The studies that were reviewed were conducted to investigate the role of using e-scaffolding in developing students' problem solving and scientific explanations and few studies were conducted to reveal the impact of e-scaffolding on enhancing students' motivation and achievement. The current study was similar to those reviewed studies as it focused on the same variables but in different context. However, it tried to investigate the impact of E-scaffolding especially with STEM students to enhance participants' questioning skills more specifically (cognition, construction, delivery and handling students' responses) and learning engagement (affective, behavioral and cognitive).

Context of the problem

To document the problem of the study, the researchers conducted a pilot study which aimed at measuring STEM students' questioning skills and learning engagement. A random sample of first year students (n=20) were selected for that purpose. The pilot study revealed that students had low performance in the questioning skills test and had displayed deficiency in their learning engagement.

Statement of the Problem

STEM Education seeks to motivate students to practice using integrated skills to solve problems and become meaningful learners and also motivate students as innovators, logical thinkers, problem solvers and technologically literates. The results of the pilot study showed that First year STEM students were in need to develop their questioning skills and learning engagement. Consequently, the present study tried to investigate the impact of using E-Scaffolding for developing STEM students' questioning Skills and learning Engagement.

Aim of the study

The researchers aimed at investigating the use of E-Scaffolding for Developing STEM Students' Questioning Skills and Learning Engagement.

Hypotheses

The following hypotheses were tested:

1. There would be a statistically significant difference between the study group's mean scores of questioning skills pre-posttest (favoring the post testing).

2. There would be a statistically significant difference between the study group's mean values of the pre-post administrations of the learning engagement scale (favoring the post administration).

Significance

The importance of the current study emerged from the following points:

1. The present study tried to fill in the gap in the review of literature about studies that dealt with e-scaffolding to develop STEM students' questioning skills and learning engagement.
2. It offered a teacher's guide for presenting the sessions using E-Scaffolding.
3. Based on the philosophy of STEM Education, the study sought to develop STEM students' questioning skills to better use them in other interdisciplinary courses such as "Knowing and Learning" and the "Practicum"
4. It tried to help students to construct higher order thinking questions to use them to state hypotheses and solve problems.
5. Throughout the experimentation students dealt with stimulating and interesting activities that really fostered students' thinking skills and learning engagement.
6. The study offered a questioning skills test with a table of specifications.
7. The study offered a learning engagement scale.

Delimitations

1. The following Questioning skills were developed:
   a. **Recognition skills**: dealing with classifying questions according to cognitive level, mode of delivery, purpose ….etc.
   b. **Construction skills**: dealing with constructing a good question that is appropriate to purpose, students etc.
   c. **Delivery skills** : including branching skills of delivering questions inside the class including the use of wait time skills, skills of distributing questions, etc.
   d. **Handling students' responses**. These are mainly concerned with evaluating students' responses, developing sensitive listening techniques, using probing (prompting, clarifying and refocusing).
2. Thirty nine students were enrolled at the first year in STEM Program; (16) were specialized in Chemistry and (23) others were specialized in Mathematics .
3. The researchers used Google Classroom https://classroom.google.com/c/NTU3NzMwMjUyNzYx?cjc=xtedk7d as an online mode to scaffold students' learning.
4. The study was conducted in the first term of the academic year 2022-2023 and lasted for twelve weeks one hour a week with an online extension.

Definitions of terms

Scaffolding

Belland (2014) defined scaffolding as a support provided by a teacher/parent, peer, or a computer- or a paper-based tool that allows students to meaningfully participate in and gain skill at a task that they would be unable to complete unaided.

Jummat and Tasir (2014, p 42) defined scaffolding as the guidance or support from teachers or other knowledgeable persons that helps students to achieve the goals . It provides them with instructions slowly shifting the responsibility to them as they develop their understanding and skills.

Scaffolding is a way to provide temporary support and direction to learners during the learning process to help them to complete new learning tasks and to encourage them to build knowledge by themselves . (E-Scholarly Community Encyclopedia ,2022).

The researchers defined E- scaffolding as graduating the support and help offered online by the instructor until students reach their goals. Learning starts with prior knowledge and ends when each student reaches his or her ultimate potentials. Students are shifted from being dependent to independent learners practicing questioning skills effectively and being highly engaged in the learning process.

Questioning Skills

According to Bhasin (2021),questioning skills are the ability to ask questions for accessing the students during the learning process.

Questioning skills are abilities that allow students to analyze concepts or situations and ask relevant questions about them. These skills can allow students to understand different aspects of classroom materials. (Indeed Editorial Team ,2023).

The skill of questioning in the current research is broken down into four branches or subskills: These subskills are recognizing the cognitive level of the question, constructing the question effectively, Delivering questions and of handling students' responses.

Learning Engagement

Student engagement is a term used to describe an individual's interest and enthusiasm for school, which impacts his/her academic performance and behavior (Gallup, 2013)

Parsons , Nuland & Parsons (2014) classified learning engagement into three dimensions as follows:

- **Affective engagement** includes a sense of belonging in the classroom and an interest, curiosity or enthusiasm around a specific topic.
- **Behavioral engagement** includes time – on - task and active participation in class activities.
- **Cognitive engagement** is a newer construct and includes the use of metacognitive and self- regulated strategies.

Lase and Zega (2021) stated that student engagement refers to the degree of attention, curiosity, interest, optimism, and passion that they show when they are learning or being taught, which extends to the level of motivation they have to learn and progress in their education.

The researchers operationally defined learning engagement in the current study as the ability of STEM students to be affectively, behaviorally and cognitively engaged in the learning experience.

Method

Research Design

The pre-experimental design where one group (n=39) pre-posttest was used. The researchers used this type of research design because the total number of first year STEM students was thirty nine .

Participants

Thirty nine students in the First year enrolled at STEM program at the Faculty of Education- Minia University participated in the study in the first semester of the academic year 2022-2023 acted as one study group.

Duration

The experiment lasted for one term. It was the first term of the academic year 2022-2023. The experiment started at the 11th of Oct. 2022 till 27th of Dec. The total number of the sessions was twelve; one hour a week with an online extension

Instruments and Materials

The researchers developed a Questioning skills test, a Learning Engagement scale and a teacher's guide.

1. The Questioning Skills Test (Appendix A)

A. Test Objective

The test was designed to measure STEM students' entry level before experimentation as (a pre-test) and to investigate the impact of e-scaffolding on developing students' questioning skills as (a post-test). A table of specifications was designed by the researchers to guarantee that the test covered the objectives. The total score of the test was 60 marks.

B. Test Construction

The Questioning Skills test was divided into four parts with fifteen marks each.

- **Part one:** For measuring students' Recognition Skills. (MCQ)
- **Part two:** For measuring students' Construction Skills (Open-ended Questions).
- **Part Three :** For measuring Students' Delivery Skills. (MCQ)
- **Part Four :** For measuring Handling Students' Responses Skills. (MCQ)

C. Duration

The allotted time for the test was two hours.

D. Test Validity

- **Content Validity**

To establish the content validity of the test, the test with its table of specifications was distributed to nine TEFL staff members. The members were asked to evaluate it in terms of; linguistic stating of items, academic verifications of the content, whether the items measure how far the objectives have been achieved, and coverage of the number of the items for the skills depicted in the test and applicability of the test. The nine jury members' suggestions were taken into consideration. They confirmed its suitability and applicability.

- **Internal consistency of the Test**

Internal consistency between each statement compared to the scale as a whole is shown in table (1).

Table (1)
Internal consistency of the Questioning Skills Test

Testing students' Recognition Skills		Testing Students' ability in Question Construction		Testing Students' Delivery and Handling Skills		Testing Students' Handling Skills	
No.	**R**	**No.**	**R**	**No.**	**R**	**No.**	**R**
1	.468*	**16**	.486*	**31**	.468*	46	.466*
2	.406*	**17**	.442*	**32**	.409*	47	.407*
3	.489*	**18**	.442*	**33**	.478*	48	.489*
4	.409*	**19**	.456*	**34**	.442*	49	.468*
5	.442*	**20**	.489*	**35**	.442*	50	.442*
6	.466*	**21**	.439*	**36**	.409*	51	.407*
7	.456*	**22**	.439*	**37**	.439*	52	.456*
8	.489*	**23**	.456*	**38**	.489*	53	.407*
9	.489*	**24**	.489*	**39**	.456*	54	.456*
10	.439*	**25**	.466*	**40**	.489*	**55**	.456*

Testing students' Recognition Skills		Testing Students' ability in Question Construction		Testing Students' Delivery and Handling Skills		Testing Students' Handling Skills	
11	.409*	**26**	.442*	**41**	.456*	**56**	.460*
12	.466*	**27**	.427*	**42**	.409*	**57**	.456*
13	.489*	**28**	.489*	**43**	.409*	**58**	.427*
14	.409*	**29**	.409*	**44**	.407*	**59**	.409*
15	.439*	**30**	.409*	**45**	.407*	**60**	.466*

Significant at 0.01

Table (2) shows that there are significant correlations between each item and its domain.

Table (2) Internal Consistency of the Questioning skills Test

Correlation between each Domain and the Total Scale

No.	The Domains of Questioning Skills Test	Correlation
1	Testing students' Recognition Skills	.572**
2	Testing Students' ability in Question Construction	.453*
3	Testing Students' Delivery and Handling Skills	.672**
4	Testing Students' Handling Skills	.556**

Significant at 0.01

E. Test Reliability

- **Test- Retest**

In order to establish the reliability of the questioning skills test, it was administered to a randomly chosen sample of 30 second year STEM students. The reliability of the test was determined by using test-retest method with two weeks intervals. The researchers and another colleague marked the test. The average score of each student was calculated. The whole test had a reliability coefficient of (0.72) and that value had a statistical significance which showed that the test had a good reliability level.

- To establish the reliability of the scale, the researchers used Alpha Cronbach formula. As shown in table (3), the reliability coefficient is (.763). It can be concluded that the scale has an acceptable reliability level.

Table (3)

The Cronbach Alpha's Reliability Coefficient of the Questioning Skills Test

N of Items	Cronbach's Alpha
60	.763

F. Piloting the test

The test was piloted by administering it to 30 second Year STEM students. Piloting the test aimed to measure its validity, reliability, appropriateness to students' level and test timing. Timing the test was computed by dividing the time taken by each student divided by the whole number of the students taking the test.

2. The Learning Engagement Scale: (Appendix B)

A. Objective

The learning engagement scale was adapted from Whitney, Cheng, Brodersen and Hong, (2019) and was used to measure students' learning engagement.

B. Construction

The scale consisted of twenty seven statements divided into three main domains; Affective, Behavioral and Cognitive with nine statements each.

C. Duration

One hour was devoted to respond to the scale.

D. Validity

- **The Content validity of the scale**

The content validity of the learning engagement scale was decided through submitting it to nine TEFL experts to establish its validity with regard to : The belongingness of the subdomains to the main domain, the importance of the subdomains to be measured, linguistic stating of the statements included, the suitability of the statements for the target participants, applicability and relatedness of the statements to the objectives of the study and if there were any suggestions, addition or omission. The jury members confirmed the suitability of the scale as it would help to assess students' engagement. They stated that the items were inclusive, easy to respond, varied and focused.

- **Internal consistency of the scale**

Internal consistency between each statement compared to the scale as a whole is shown below in table (4)

Table (4)
Internal Consistency of the Learning Engagement Scale

Affective		**Behavioral**		**Cognitive**	
No.	R	No.	R	No.	R
1	.549**	10	.644**	19	.423**
2	.549**	11	.493**	20	.510**
3	.549**	12	.530**	21	.560**
4	.506**	13	.478**	22	.484**
5	.556**	14	.478**	23	.489**
6	.506**	15	.498**	24	.478**
7	.677**	16	.456**	25	.469**
8	.555**	17	.510**	26	.485**
9	.493**	18	.442**	27	.815**

**Significant at 0.01

Table (5) shows that there are significant correlations between each item and its domain.

Table (5) Internal consistency of the Learning Engagement Scale

Correlation between each domain and the Total Scale

No.	The Domains of the Learning Engagement Scale	Correlation
1	Affective	.452*
2	Behavioral	.454*
3	Cognitive	.418*

*Significant at 0.05 level and beyond

From table (5), it can be inferred that the correlation of the first domain (Affective) and the total score of the scale is (.452), the correlation of the second domain (Behavioural) and the total score of the scale is (.454) and the correlation of the third domain (cognitive) and the total score is (418) . This proves that the scale has internal consistency between its subdomains. It can be concluded from table (4) and table (5) that the scale has good internal consistency.

E. Reliability

To establish the reliability of the scale, the researchers used Alpha Cronbach formula. As shown in table (6), the reliability coefficient is (.738). It can be concluded that the scale has an acceptable reliability level.

Table (6) The Cronbach Alpha's Reliability Coefficient of the Learning Engagement Scale

N of Items	Cronbach's Alpha
27	.738

F. Piloting the learning Engagement Scale

The scale was piloted by administering it to 30 second Year STEM students. Piloting the scale aimed to measure its validity, reliability, appropriateness to students' level and to compute its timing. Timing the scale was computed by dividing the time taken by each student divided by the whole number of the students taking the scale.

The Teacher's Guide **(Appendix C)**

The teacher's guide consisted of twelve sessions. They are as follow:

Session One: Bloom's Taxonomy
Session Two: Inquiry Questions; The Bigger the Better.
Session Three: Egypt's Grand Challenges.
Session Four: Webb's Depth of Knowledge
Session Five: Building up a rubric for assessing the oral production of questions.
Session Six: Forming Inquiry Questions related to an article entitled "Gravity".
Session Seven: Forming Inquiry questions related to an article entitled "Eight Environmental factors that Affect Health"
Session Eight: Forming Inquiry Questions related to an article entitled "Energy".
Session Nine: Questioning Strategies
Session Ten: Effective presentation Skills.

Session Eleven: Assessing Students' E- portfolios .
Session Twelve: Assessing Students' E- portfolios (Cont.)

Role of the Instructors

The instructors' role was to post the material on the Google Classroom before the session as to give them enough time to have exposure to the selected material. A number of carefully You-tube videos and related articles were posted before each session. The instructors had to ask thought provoking questions to stimulate students' thinking and scaffold students' learning. In in-class activities the instructors had to give a short introduction about the topic and conduct a number of well planned activities such as gallery walk, brainstorming, think – pair-share, …..etc. The instructors had to review students' assignments on the assigned Google classroom and give students sufficient constructive feedback.

Role of the Students

Students were divided into groups. All students were logged in Google Classroom" STEM Level 1". In this group they received the content and delivered the assignments. They also reflected on the uploaded videos and the posted articles.

Activities

E- Activities

- Watch and reflect
- Group Discussion
- Simulations
- Scenario Based Assessments
- Adaptive e- learning Activities

In-class Activities

- Brain storming

- Group work
- Discussion
- Gallery walk
- Workshops
- Formal and Informal Conversations

Evaluation Techniques

- Short Answer Questions
- Quizzes
- Assessing students' oral production of questions.
- Mini-presentations
- Assessing students' e-portfolios.
- Reflection log

Pre-testing

At the beginning of the experimentation, the researchers noticed that the students were reluctant to participate and their questioning skills and learning engagement level were quite low. This could be obviously seen in their performance in the pre-testing of both the questioning skills test and the learning engagement scale (See table 7 and 8). The researchers announced the objectives of the experiment and students were added to a Google classroom and a WhatsApp group.

Experimentation

Participants received twelve sessions one hour a week with an online extension. Participants were divided into groups. Before each session the researchers posted the material on the predetermined Google classroom. Students were able to view the material according to their pace. They were given tasks to prepare at home and be ready for classroom activities and discussions. Throughout the experimentations participants were involved in a number of e-activities and classroom ones. Students were e-scaffolded by:

- **Chunking materials**

The researchers broke down the material into chunks where learners had to reflect, question or even reach out for help.

- **Encouraging Metacognition**

Metacognition refers to learners' ability to evaluate their own learning. The ultimate goal of scaffolding is to enable learners to achieve their course learning objectives without aid. Learners' ability to recognize their strengths and weaknesses is a critical step towards that type of mastery. One scaffolding method that was mainly used in this research was reflection. Learners were given reflective exercises where they had to recall, recapture (capturing emotions, accomplishments and challenges), relate (identify connections with previous materials or experiences), rationalize (identify patterns and create meanings) and redirect (Think about the future).

- **Providing Examples**

Providing examples was a scaffold in the sense that students could compare the work they were completing to the work they knew you were expecting. This in turn enables learners to identify their deficiencies and make corrections.

- **Breaking down assessments**

The researchers broke down assessments into more manageable subtasks. Throughout the course students were given assignments where they had to accomplish individually or in groups. At the beginning of each session theses assignments were presented by students and they were given sufficient feedback.

- **Aligning Assessments**

One of the main philosophies of STEM education is the integration between its subject matters. In "English for STEM 1" learners were asked to form related questions to the other interdisciplinary courses such as the Practicum and Capstone. Additionally, the types of assessments used in the course whether formative or summative assessments were consistent. During the course learners were given tasks and assignment where they had to fulfill individually or in their groups. They delivered these assignments in the prescribed Google classroom and received feedback. During the experiment they were asked to prepare a group e- portfolio where they had to present it at the end of the experiment.

Post Testing

At the end of the experimentation, students were post tested using the questioning skills test and the learning engagement scale. They were asked to write their views in a reflection log. Data were treated statistically and the findings are within the following section.

Findings

Hypothesis one

Hypothesis one predicted that there would be a statistically significant difference between the study group's mean scores of questioning skills pre-posttest (favoring the post testing). Statistical analysis shown in table (7) indicated that this hypothesis was accepted as participants' post testing exceeded their pre- testing and the't' value was (76.719) and this value was significant at 0.01.

Table (7)

Means, Standard Deviations, t-values, and Cohen's d and the Difference between Mean scores obtained by the Study Groups' Pre-Post Testing on The Questioning Skills Test

Variable		Mean	No.	Std. Deviation	t- value	D. F	Cohen's d	Sig.
Testing students' Recognition Skills	Pre	3.25	39	1.60128	**32.208	38	5.16	<.001
	Post	13.69	39	1.25978				
Testing Students' ability in Question Construction	Pre	3.28	39	1.43176	**31.627	38	5.06	<.001
	Post	13.79	39	1.32147				
Testing Students' Delivery and Handling Skills	Pre	3.23	39	1.32708	**29.859	38	4.78	<.001
	Post	12.12	39	1.54203				
Testing Students' Handling Skills	Pre	2.94	39	1.29673	**25.632	38	4.1	
	Post	12.53	39	1.61972				
Questioning Skills Test as a Whole	Pre	12.72	39	2.554	**76.719	38	12.28	<.001
	Post	52.15	39	2.570				

**Significant at (0.001) level

Hypothesis Two

Hypothesis two predicted that there would be a statistically significant difference between the study group's mean values of the pre-post administrations of the leaning engagement scale (favoring the post administration). Statistical analysis shown in table (8) indicated that this hypothesis was accepted as the participants' post testing exceeded their pre-testing and the 't' value was (43.225) and this value was significant at 0.01.

Table (8)

Means, Standard Deviations, t-values, and Cohen's d and the Difference between Mean scores obtained by the Study Groups' Pre-Post Testing on The Learning Engagement Scale

Variable		Mean	No.	Std. Deviation	t- value	D. F	Cohen's d	Sig.
Affective	Pre	13.07	39	1.61	**40.087	38	6.42	<.001
	Post	24.71	39	1.63				
Behavioral	Pre	11.97	39	1.63	**28.122	38	4.5	<.001
	Post	23.23	39	2.40				
Cognitive	Pre	12.33	39	1.91	**24.253	38	3.88	<.001
	Post	23.00	39	2.33				
The Learning Engagement Scale as Whole	Pre	37.38	39	3.91	**43.225	38	6.92	<.001
	Post	70.95	39	5.10				

**Significant at (0.001) level

Discussion

The study was a pre-experimental one conducted to investigate the effect of using e-scaffolding on developing STEM Students' questioning Skills and learning Engagement. Thirty nine first year students enrolled at STEM program participated in the study and acted as one study group.

Students' performance in the pre-testing was low whether in the questioning skills test and in the learning engagement scale. At the beginning of the experimentation, the researchers announced the objectives of the experiment and the importance of using e-scaffolding in the EFL classroom. Students were motivated and were excited to participate. The researchers created Google classroom account and asked the participants to join it. Through it students could receive the assigned material, assignments, and submit their assignments .It encouraged virtual discussions of and reflections on classroom tasks. Throughout the experimentation students were e- scaffolded by chucking materials, encouraging metacognition, providing examples , breaking down assessments and aligning assessments.

In the current, study the researchers sought to measure participants' questioning skills- namely; recognition skills, construction skills, delivery skills and handling students responses before and after the experimentation . From the results obtained in table (7), it could be noticed that students performance in the post testing of the questioning skills test (52.15) exceeded their performance in the pre- testing (12.72) as the effect size was found to be (12.28) and this value is much satisfactory to the researchers because according to Cohen (1988), a generally accepted minimum level of statistical power is 8.0. This value refers to the high effect of using e-scaffolding on students' questioning skills.

It is important to mention that the researchers started developing students' questioning skills through acquainting them with Bloom's taxonomy. They were asked to identify and construct questions according to Bloom's taxonomy. The researchers emphasized that questions should be used purposefully to achieve well defined goals. The researchers highlighted the conditions where lower and higher level questions were to be used.

The researchers then trained students to form inquiry questions stressing the necessity to form bigger questions that stimulate higher order thinking. Students were familiarized with kinds of inquiry questions and were asked to form a number of inquiry questions after watching videos such as a You-tube video about " Global warming .

One of the main philosophies of STEM Education is to relate the subject matters with community problems Therefore, students were confronted with " Egypt's Grand Challenges" such as "reducing pollution", "reducing urban congestion", "improving the use of alternative energies", "improving sources of clean water", "dealing with exponential population growth"…..etc . They had to form inquiry questions related to these topics.

Additionally, students discussed "Webb's Depth of Knowledge" model. They were familiarized with each level of the model and the desired products as well as the roles of both the teacher and the student in each level. They were asked to read articles posted on Google Classroom about "Gravity" , "Energy" and " Environmental facts that affect Health". and form inquiry MCQ questions .

Students were also introduced the strategies related to delivering questions and handling students responses. Students then were asked to build up a rubric for estimating the oral production of questions. Finally they were introduced the basics of effective presentation, as from the very beginning they were asked to develop an e-portfolio. This e-portfolio includes all the assignments, quizzes, photos and reflections about the course. Examples of these reflections may include:

- *"This course helped me in other interdisciplinary courses such as Knowing and Learning, Capstone and the Practicum where I had to pose inquiry question".*
- *"This course is so beneficial because we learned the level of thinking and how to determine the type of question and for the first time we knew about inquiry question"..*
- *"The methods used in the course (Whats App group, Google Classroom and QR Code) helped us in receiving tasks and viewing the material of the upcoming lecture".*
- *"The instructors were really helpful and active".*
- *"The course helped me to form questions representing different levels of Blooms' taxonomy and Webb's Depth of knowledge".*
- *" The online tasks helped me to keep on track and fostered my comprehension"*

From examining the effect size of each skill , it could be noticed that the most emphasized questioning skill is the "Recognition Skill" (5.16) and the least one was " Handling students' responses" (4.1) perhaps by the time it will be much more developed through students interaction in the Practicum at STEM schools. Thus the current study confirmed the positive impact of using e-scaffolding on developing STEM students' questioning skills. This conclusion came in accordance with studies conducted by Mulyono and Rosyida (2022); Cetin (2021), Amelia, Rofiki, Tortop and Abah (2020); Nurramadhani, Lathifah and Permana (2020) Koes, Suwasono and Pramono (2019); Rajaram (2019), Nor'Aida Khairuddin , Harmeni, and Radzali (2019)Saman, Koes and Sunaryono (2018); Belland , Walker, Oslen and Leary (2015).

E-scaffolding could manage to develop students' learning engagement (See table 8) as students' performance on the post administration of the learning management scale was (70.95). It exceeded their pre-performance which was (37.38) and the effect size reached (6.92). Throughout the course students participated in online activities such as " Watch and reflect", " Group Discussion", " Scenario based assessments" …etc. It was concluded that e- scaffolding managed to engage STEM students in their learning . It helped students to reach to their potential abilities. Every student participated actively in the Google Classroom and in the in-class activities. Students had reported themselves feeling more confident and quicker to grasp the content. E-scaffolding had proven not to be out of the social constructivist scope and was adapted to the actual abilities of students. Consequently, the current study confirmed that E- scaffolding managed to develop STEM students' learning engagement. This conclusion came in accordance with Struyf et.al (2019), Thibourat et.al (2018) and Hardijito (2010).

Conclusion

E-Scaffolding is largely influenced by the concept of zone of proximal development. Ideally, it helps to support students as they move toward being able to complete a task without help. E-Scaffolding can take several different forms; from breaking down larger assessment into subtasks to providing examples and encouraging reflection. E-scaffolding constructs the student’s thinking and helps students to grasp fundamental conceptual understanding in developing ways of finding solutions and direct their attention to identifying goals and constraints on solutions. E- Scaffolding managed to develop learners' questioning skills and learning engagement.

Challenges

- Planning for and implementing E-scaffolds may take time from the part of the instructor.
- Selecting appropriate scaffolds that match the diverse learning and communication styles of students need effort and skills.
- Knowing when to remove the scaffold so the student does not rely on the support.
- It is important to know the students well (their cognitive and affective abilities) to provide appropriate scaffolds.
- Providing constructive feedback to students is essential when using e-scaffolding.

Recommendations

In the light of the results obtained in the present study, a number of recommendations could be drawn:

1. EFL instructors are strongly advised to incorporate e-scaffolding techniques in teaching their courses.
2. Developing STEM Students' questioning skills have to be one of the priorities in the teaching-learning process.
3. To create long lasting learning, providing an ongoing feedback is the best way to demonstrate results.
4. More attention should be given to the methods and techniques that encourage the involvement of the learning act.
5. More emphasis should be given to metacognitive activities.

Suggestions for further research

1. Investigating the impact of using E-scaffolding on developing STEM students' metacognitive skills.
2. Investigating the impact of using E-scaffolding on developing STEM students' oral communication skills.

3. Investigating the impact of using E-scaffolding on developing STEM students' written communication skills.
4. Investigating the impact of using E-scaffolding on developing STEM students' academic achievement and motivation.
5. Further research studies are needed to compare between e-scaffolding and other instructional strategies on other group samples and contexts.

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مستخلص البحث

ستخدام السقالات الالكترونية لتنمية مهارات التساؤل والإندماج في التعلم لدي طلاب ستيم

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هدفت الدراسة إلي التعرف علي أثر استخدام السقالات الالكترونية في تنمية مهارات التساؤل والاندماج في التعلم لدي طلاب ستيم. قامت الباحثتان بتدريس مقرر اللغة الانجليزية لطلاب ستيم وذلك في الفصل الدراسي الأول من العام الأكاديمي ٢٠٢٢–٢٠٢٣. وتبنت الدراسة الحالية المنهج شبه التجريبي القائم علي إستخدام المجموعة الواحدة ذات إختبارين قبلي وبعدي. حيث شارك في التجربة ٣٩ طالب وطالبة من طلاب الفرقة الأولي ببرنامج ستيم : (١٦) تخصص الكيمياء و (٢٣) تخصص الرياضيات. ولتحقيق أهداف الدراسة قامت الباحثتان بإعداد اختبار مهارات التساؤل , وإعداد مقياس الاندماج في التعلم . كما قامت الباحثتان بإعداد دليل للمعلم والقائم علي استخدام السقالات الالكترونية. وتلقي الطلاب اثني عشرة محاضرة بمعدل ساعة اسبوعيا بالاضافة الي امتداد الكتروني . وأظهرت النتائج وجود فروق ذات دلالة إحصائية بين متوسطي درجات الطلاب في التطبيقين القبلي والبعدي في مهارات التساؤل والاندماج في التعلم لصالح التطبيق البعدي.

الكلمات المفتاحية: السقالات الإلكترونية– مهارات التساؤل– الإندماج في التعلم.