Reinforcement of student-centered learning through social e-learning and e-assessment

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Abstract
Student-centered learning has become more effective approach through utilizing of internet and electronic devices in interactive and social learning environments. During Covid-19 pandemic, interactive and social learning have significant role in conducting learning process at educational institutions. This study introduces new module based on students-centered format to examine recent known evaluation methods through interactive and social learning. Science, Technology, Engineering, and Mathematics (STEM) are the most sciences facing several challenges during social learning based on the nature of their courses and using mathematics and related practices. Mixed method of quantitative and qualitative data analysis were adopted to conduct the objectives of study. Six expertise in STEM were chosen for interviews to investigate and develop e-learning module and a sample of 623 students were selected to evaluate assessment module. This study developed PADA module through conducting workshop among educators and students in selected Islamic universities in Indonesia. The module has many benefits to conduct successful interactive and social learning during Covid-19 pandemic. The results also revealed that multiple choice format was more accurate than true–false format and short answers format for e-assessment. More instructions for re-use of this module have been represented as part of this study.

Keywords Social learning · e-learning module · STEM · E-assessment · Higher education

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Introduction

Recently, Social learning has become significant approach to conduct e-learning all over the world due to the covid-19 pandemic. Different practices were adopted by many universities to overcome challenges facing Social learning. Besides, many of higher education institutions have gained comprehensive experience during last two years and most of interactive (online/hybrid) classes were conducted successfully (Garad and Al-Ansi 2021). Some of the main challenges were related to STEM courses where students have to do more practices. STEM students, more than others in different courses, need more effective tools and approaches to gain the appropriate knowledge. Using mathematics and complicated equations, theoretical practices and insufficient tools led to many problems for both educators and students (Al-Ansi 2020). Based on these facts, many of educational institutions have developed different modules and incentives to enable effective learning. In Indonesia, on med-2020, Ministry of Education collaborating with some top universities have recommended some modules and approaches to adopt interactive learning and effective approaches to evaluate student’s performance. Higher education learning environment has been modified to emerge a new era of comprehensive quality improvement and innovation. In the era of innovation, the teacher-based teaching mode of university STEM courses is facing more and more severe challenges. This paper will explore how to break the “indoctrination” classroom teaching and reshape the new class-teaching mode of university STEM courses. In this way, the efficiency of students’ learning in class maximized, and talents with critical thinking and ability are cultivated in response to the innovation requirements of the times. In addition, the evaluation process during the Social learning is becoming more challenging where educators use many different evaluations’ styles. This paper will compare among three most used evaluation approaches.

In an effort to build modules and provide appropriate training for researchers comprising graduate students and academics, there are several challenges in STEM learning that have been identified, among them are emotional instability (Janke et al. 2020)), financial constraints, time constraints (Brutus et al. 2013), lack of experience (Alharbi 2019), and individual attitudes (Pineteh 2014).

In addition to some difficulties in using social media and online applications, emotional instability was found to be one of the major dilemmas and challenges faced by young academics in teaching STEM (Al-Ansi and Suprayogo 2019). They feel anxious if the teaching does not conform to standards, and this feeling drags down to the performance because more time and effort is required for learning. The tedious e-learning process that involves reading, repetitive writing, multiple formatting, and other steps in curriculums causes emotional instability among young academics. Kara (2013) asserts that academic researchers involve a lot of emotions, and emotions are inevitable in their work. Kara (2013) suggested that educators should learn to channel emotions in their academic teaching in order to better present their courses to students. Sword et al. (2018) pointed out that educators are also often frustrated in ICT-based learning materials because
they often face many difficult and lack of required skills. This frustration also contributes to a sense of despair and failure to rise in rank as well as strengthen learning on a global scale.

On the other hand, the evaluation process of students’ performance remains one of the main challenges during Social learning. Three more effective approaches during assessment process of Social learning could be considered as follows: True–False (TF), Short Answer, and Multiple choice format. There may be doubts expressed by examiners regarding comparability of scores obtained using the various objective test formats. Such examiners may not have empirical evidence to support their position (Esomonu et al. 2020). It therefore becomes necessary to compare scores from the three objective formats to see if they are comparable. Objective tests are tests in which students are provided with a specific problem and given limited number of choices from which they could make choice of the correct answers or to supply answers limited to not more than three words, or at most a phrase. Objective test formats consist of true–false, short answer, and multiple choices, among others (Eleje, et al. 2017).

True–False (TF) format is a type of objective test format that allows only two options to a question. Its items have the advantage of having more content sampling and wider material coverage than any other item format ((Eleje et.al 2016; Okoye 2015). According to Chandratilake et.al (2011), the chance of guessing in TF item is 50%. Hence, there is strong possibility that students can score higher marks by chance in TF format than other objective test formats.

Short-answer item format is a type of objective test format in which students are asked to provide a short answer to a question or finish an incomplete statement by filling in a blank with the correct word, number, symbol, or short phrase (Thawabieh 2016). Short-answer item formats are deemed more appropriate than multiple choice and true–false items for measuring high inference mental skills or abilities where the examiner is expected to construct an answer (Nuri & Ceylan 2016).

Multiple choice format is one of the objective test formats that give room for easy scoring. It consists of a stem which provides the student with a problem and then a list of possible answers. There is little doubt that multiple-choice test format is cost-saving and capable of providing reliable and valid inferences about some kinds of conceptual knowledge (National Research Council 2012). However, multiple-choice test items cannot be used to assess the ability of the student to organize and summarize ideas (Okoye 2015). Other disadvantages of this format include that it takes time to construct and gives room for guessing (Eleje and Esomomu 2018). These disadvantages are capable of influencing students’ academic achievement.

Out of the three objective test formats, the one to choose seems dependable on the examiner’s preference. Likewise, Javid (2014) investigated the comparison between Multiple-choice (MC) and True–false Test formats in Iranian Intermediate EFL learners’ vocabulary learning using survey research design. The instruments used in this study were 50 multiple-choice grammar and vocabulary items used as a pre-test and standardized multiple choice tests used as the post-test. Data collected were compared by using Mann–Whitney U test. The results of the statistical analysis revealed that there was a significant difference in the performance of students in
favor of true–false. Additionally, researchers have equally showed that gender impacts student’s academic achievement (Eleje, et al. 2020; Thawebieh, 2016).

Thus, after identifying the challenges and gaps in previous studies, this study aims to improve the skills that need to be present in postgraduate students and academics in university level. Among the skills that need to be possessed are educator’s skills, students’ skills, and well preparation of university infrastructure and learning management systems. The skills that will be improved through the use of the e-learning Module is expected to help academics and students to achieve excellence in their careers and studies.

Literature review

Theory-based design of teaching & learning materials

Theories are aimed to define and explain an event or phenomenon (Silverman, 2017). There are three theories used when developing this module, namely Self-Determination Theory, Social Constructivism Theory, and Successful Intelligence Theory. These theories were chosen because they fit the needs of a study that requires course participants to be able to make decisions and actions for self-success, while leveraging a conducive and encouraging environment in producing quality e-learning.

Self-determination theory (SDT)

This theory is applied to activities that are engaging, challenging, or fun. It is an activity that requires no experience or extrinsic reason to do so (Deci & Ryan, 2004). Self-Determination Theory, or SDT, is a theory that links personality, human motivation, and optimal functioning. It asserts that there are two main types of motivation—intrinsic and extrinsic—and both are powerful forces in shaping who we are and how we behave (Deci & Ryan, 1985). This is a theory that evolved from Edward L. Deci and Richard M. Ryan’s research on motivation in the 1970s and 1980s.

In the context of e-learning, the internal motivation of course participants is expected to be a catalyst for their success in completing a given assignment within a set period of time. The expected internal motivation is a feeling of love for the activities that make the efforts of learning successful. Meanwhile, the external motivation received was from the facilitators and participants who also exhibited their progress during the training or course. The most effective external motivation is when course participants manage to learn effectively and use required applications of e-learning efficiently.

Social constructivism theory

According to Yildirim (2014), constructivism is a contemporary theoretical approach that greatly influences education systems around the world. It is a student-centered
educational approach so that the information provided can create meaning and structure through the relationship between past experiences and new information. According to the study of Eva Sivan (2010), motivation in the classroom is based on theories that focus on the intra-psychological properties of the individual or her/his cognitive and/or affective functions. In contrast to the individualistic perspective, constructivist social theory features motivations derived from external influences such as training and a conducive environment.

In the context of this study, Social Constructivism theory features a culture of academic learning and mastering of different e-learning materials and applications that not only involves teaching, but extensive exposure is given to the production of research papers, e-materials, conference conducting, and early exposure that help graduate students prepare in involving in teaching. A culture based on a love of knowledge and a love to disseminate knowledge for the benefit of the world class teaching makes this study highly impactful in building a social environment that builds and promotes academic excellence.

**Successful Intelligence (SI) theory**

Sternberg’s Theory of Successful Intelligence divides intelligence into three working components, namely analysis or components; second, practical or contextual; and third, creative or experiential. Analytical or extraction intelligence refers to the higher order mental processes involved in problem solving. In short, analytical ability is required in the process of analyzing, evaluating, criticizing, reasoning, and evaluating. People with high analytical intelligence are seen to excel in standardized tests of academic potential (Sternberg et al. 2006).

In the context of this study, this theory is used to strengthen the motivation together to achieve success in the course. In the constraints of time as an educators and students, the success of conducting Social learning effectively by using different applications and creating appropriate e-materials are very meaningful and exciting. The three analytical, practical, and creative aspects of this theory play a role in the thinking and actions of course participants to achieve the dreamed success. Thus, these three theories have been used as a platform by the researcher to produce successful e-learning Module, as illustrated in Fig. 1.

![Theoretical Framework](image)
There are three theories used as a basis in the development of this e-learning module. The selection of the theory of self-determination is based on the research problems that have been identified. Since this study aims to develop the successful e-learning Module in STEM, social constructivism theory and successful intelligence theory were identified to be used as a backup in building this module. The appropriateness of these theories is also because they contribute to motivation e-learning, critical thinking, and the use of past experience, as well as a determination to achieve success through intelligence in analysis, practicality, and creativity. These three theories are used as a backup to build the module.

The teaching status of STEM in university

1. Now the Educators “full hall” teaching method is dominating the majority of college STEM classes. Students passively accept the knowledge. This kind of class makes it difficult for students to participate in studying and to experience the fun of learning. The lack of interaction and thinking collisions between teachers and students and among the students is not conducive to the cultivation of students’ distinguishing and cooperative spirit.

2. At present, the teaching content of STEM courses learns according to the content of the textbooks. The application of knowledge or the background of the examples is both outdated and uninspired. The knowledge that students receive in online classes is almost unrelated to their actual life experience and information obtained from all sides. Such classes actually stifle students’ interest in learning.

3. In traditional STEM classes, most teachers teach in accordance with the routine of “definition-theorem-proof-inference-example,” and the teaching mode is single and rigid. This kind of teaching routine is difficult for students to concentrate for a long time (Yongwang 2019). The lack of well-designed classroom teaching is not conducive to mobilizing students’ enthusiasm for learning.

4. Many universities have made great achievements in the field of teaching mode exploration of flipped classroom, and have accumulated a lot of experience. However, flipped classroom is not fully applicable to the teaching of STEM course. On the one hand, due to the particularity of some of STEM courses, the theory is obscure and logical, but the students’ narration usually cannot touch the depth of teachers’ intention. On the other hand, STEM courses often teach high number of students at the same time, so the flipped format cannot cater for all students in the class.

5. This is a highly information age (Furong 2020). However, textbooks, PPT, and blackboard writing are still the main teaching tools in the STEM in universities, lacking the use of information means, which is not in line with the requirements of the modernization of education in the new era.

In short, the present classroom teaching of STEM takes teacher’s lectures as the main method of knowledge transmission, textbooks, PPT, online applications as teaching tools, and definitions, theorems, proofs, inferences, examples, exercises as paradigms. This is contrary to the “student-centered” educational reform concept proposed by us in the era of teaching innovation (Haoxiang 2020). It not only
hinders the improvement of students’ interest in learning, but also is not conducive to the cultivation of students’ independent thinking habit, critical thinking custom, innovative spirit, and collaborative ability.

**Methodology**

Collection of interview information and through reading the library including making references from books, journal articles, reports and related policies were conducted to assist in determining the content of the module. This approach is suitable to obtain sufficient information in making an accurate justification and in accordance with the scope of the study that is the preparation of the draft module (Mahmud et al. 2017).

**Design phase**

The e-learning module is designed based on the needs analysis and problem statements that have been discussed in this study. The next step is to select and organize the content, the selection of effective technology for the activity, and the selection of resources that suit the needs of the students. The selection of these theories and models also guides lecturers and students to consider the findings from the analysis phase as input for this phase. In the previous phase, the findings of the student questionnaire were enriched with lecturer questionnaires along with interviews of lecturers and experts. Figure 2 shows the module preparation framework at the design phase.

Figure 2 shows the design framework of e-learning module preparation. There are two domains in the production of this module namely motivation and skills. There are four basic skills for researchers, namely researching, reading, writing, and monitoring. After that, from the two main domains, it is broken down into three subtopics

![Fig. 2 Design phase](image-url)
of the module, namely the Falling in Love Submodule, Writing Submodule, and Monitoring Submodule. This submodule becomes the main topic or chapter in the e-learning module. The motivation submodule is the first section that will discuss about love in learning/teaching and an introduction Social learning. Next, the second part is the preparation Submodule which will explain about creating e-materials, using video call applications, and using learning management systems and the characteristics of quality courses. When users are exposed to this information, they will be able to understand the basic concepts in Social learning. The last section is the assessment Submodule which will discuss about the potential of students’ performance, the process assessment, and the criteria of this assessment.

**Developing phase**

The development process begins with the determination of equipment for e-learning which includes the formation and selection of appropriate teaching materials according to the content of learning through a two-day course. The development phase also takes into account the formation of more efficient and appropriate teaching strategies. Once the determination of the software and equipment is made, the module authoring activities are done in detail based on the information from the design phase. Module development is divided into three parts namely leaning, preparation, and assessment. Once the e-learning module is ready to be developed, the draft module will be piloted in a two-day course.

In this development phase, the process involved is creating intuitive pathways (intuitive awareness), identifying learning objectives, creating teaching methods and materials, creating interactive communication methods, and creating support materials for students in creating love to learn and assessment modules according to design specifications predefined module form. At the end of module development, module testing is conducted by a six-person panel of expert evaluators. The purpose of this testing conducted is to verify whether the modules that have been developed meet the specified specifications and the module improvement process is based on the results of expert feedback (Jamaludin Harun et al. 2003).

The panel of expert evaluators was given a draft of the modules that had been produced along with an expert validation checklist detailed according to the subsections of the instrument based on their respective areas of expertise. Expert confirmation will be given through feedback in the checklist for the e-learning module testing process. In the context of module content, academic in curriculum and ICT developers were asked to provide feedback based on the content of each STEM learning topic. Multimedia experts lead to feedback on slides, audio, and graphics. Instructional design experts responded to the design of the e-learning module with self-directed learning methods and problem-based learning methods to determine that the module met these criteria. All written responses will be recorded and analyzed for the purpose of this study.
Evaluation process

In addition, module testing was also conducted among students and academics during the pilot study. The results of the checklist feedback from the experts and respondents of the pilot study were recorded and analyzed according to the theme of the term code that has been determined for the purpose of improving the e-learning module. A pilot study of the use of the module was conducted in a two-day writing workshop. The respondents of this pilot study met the same characteristics as the actual study. This study was conducted to test the module and identify any content problems or procedures for the use of e-learning modules. The problems identified will be corrected until there are no more problems during the actual study.

The evaluation process adopted a 2 × 3 mixed ANOVA design. The population of the study comprised 5793 (2684 males and 3109 females) including students and educators in Islamic University. The choice of STEM students was underlined by the fact that this was the stage where students were given the opportunity of selecting their subjects of choice in advance preparation for learning virtually. The sample of the study comprised 623 students and academics of 2018/2021 academic session obtained through multi-stage sampling procedure. Three instruments were used for data collection. Each of them was an achievement test titled “STEM” covering 10 units of 2018/2021 that they were constructed using different test formats viz: short answer, true–false, and multiple choice. Each of the tests contained 25 items. Copies of the three different achievement test formats (one constructed with short-answer item format, the second with true–false item format, and the third with multiple-choice item format) were given along with the purpose of the study, research objectives. In estimating the reliability coefficient, each of the items was scored dichotomously, that is for each item, a mark was awarded for a correct answer and zero for a wrong answer. Reliability indices of 0.76, 0.78, and 0.83 were, respectively, found for short-answer item format, multiple-choice item format, and true–false item format, and so were considered high enough to confirm the instruments as reliable. Three different groups were used for the study, and each participant was exposed to the three test formats on three different days to avoid testing effect. In scoring the instruments, one mark was awarded for each correct response. Mean and standard deviation were used to answer the research questions. The computation was done using a Statistical Package for Social Science (SPSS), Version 23.

Results and discussion

Characteristics of needs analysis phase study participants

For the needs analysis phase, a total of 10 students of the 2019 cohort group and 10 academics were selected for the purpose of analysis. They were selected based on purposive sampling because they were expected to provide complete feedback on the needs of the study (Creswell and Creswell 2017). All study participants met the criteria that have been set, which is to have high expertise and knowledge,
qualifications exceeding five years, and ready to be a respondent in a long period. The sample size was selected based on the views of Fraenkel et al. (2012) that is in the qualitative study the number of participants is between 1 and 20 people. However, Spencer and Spencer (1993) found that the number of study participants was sufficient as many as seven (7) people to obtain valuable qualitative data. Meanwhile, Patton (2002) argues that a small number of samples helps researchers acquire information in more depth. The determination of the sample size is also seen based on the recommendations of researchers in the field of analysis and system design. Satzinger et al. (2007) argue that a small number of samples is sufficient if the design objectives are clear and limited.

**Characteristics of design and development phase study participants**

The results of the analysis and feedback in the needs analysis phase are recorded and used as a guide in the module design process. The design phase is an important phase because the selection of study participants influences the quality of the study. In the development phase, a total of six expert evaluators acted as a panel to review and validate the module in terms of content, illustrations, information organization, and graphic content. Hsu and Sandford (2007) suggested that a panel of research experts be selected among those who have expertise in the field under study, are capable and willing to engage in research as well as have the skills to communicate. The usability test of the module was conducted during the testing phase on 20 students and 20 academics during a pilot study conducted during a two-day learning course.

**Characteristics of evaluation phase study participants**

For the evaluation phase, a total of 20 students and 20 academic participants were involved in the study. Participants of this study registered online through course announcements. However, after the course was conducted, only 15 students and 15 academic participants met the set criteria. Among the criteria are the agreement to be a study respondent, not yet have the rank of Associate Professor and study or work at Islamic universities Indonesia. Once the course registration was made, the researcher built a WhatsApp group to gather all course participants to make a note again that this course is suitable for those who are training to use e-learning module, do not have e-learning experience, and individuals who want to improve their e-learning skills Table 1

The selection of study respondents was based on three phases involved in the e-learning module development workflow process as shown in Table 2.

**Evaluation**

Mean and Standard Deviation Scores of STEM Students Exposed to Short-Answer, Multiple-Choice, and True/False Item Formats ($N=623$).
| Phase                          | Steps                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Goal construction             | In general, the goal of module construction is intended as an intervention for students and young academics. In the goal building process, the results of needs analysis are used to identify the theme of the needs of a module or activity in the module. For example, the results of the needs analysis show that the module requires the integration of theory and practice. Therefore, the goals are built towards the theme of how to combine theory and practice and be able to explain the content of the activity |
| Identifying theories, concepts, targets, and duration of the course/workshop | Identify relevant theories to explain the variables measured in accordance with the problems faced by students and academics. In addition, the concept used in the construction of this e-learning Module is user simplicity and effective mentoring through continuous monitoring in the participants’ WhatsApp’s group                                                                                     |
| Requisite study               | A requisite study was conducted to identify module construction needs. In this study, the requisite study was done through two methods, namely, document analysis and questionnaires. The findings of the requisite analysis study have been discussed in the study problems                                                                                                               |
| Setting objectives            | Objectives are divided into two, namely, general objectives and specific objectives. The general objective is to describe the overall objectives to be achieved in the implementation of the module. While the specific objective is the purpose of each submodule or activity implemented and evaluation                                                                                                    |
| Content selection             | Content was constructed and selected based on theory because each activity is able to explain the variables. In addition, the selection of content will also influence the objectives of each activity. Appropriate content selection will be made based on the domain                                                                                           |
| Strategy selection            | The choice of strategy will take into account the level of understanding of the facilitator, the suitability of the participants, the location or place of running the program, and the appropriateness of the meeting time. All these factors will be taken into account to determine the smooth implementation of the module and thus impact the effectiveness of the module                                      |
| Logistics selection           | Logistics selection includes the materials to be used in each activity, the suitability of the location or venue of the program, facilitator training, and participant safety. The researcher will provide a checklist as a guide manually to ensure that the logistical requirements are satisfactory and meet the criteria to be set                                                  |
| Media selection               | The delivery method of the module will take into account the needs of the activity which is a combination of several methods of delivery medium that is through the Microsoft Teams platform. In addition, teaching aids such as internet connectivity, video clips, WhatsApp, and Power Point applications will be used to attract participants to be actively involved in each activity |
Results presented in Table 3 indicate the means and standard deviations of students exposed to short-answer, multiple-choice, and true–false item formats. The mean scores of 17.09, 21.34, and 18.58 reported in the table show that students’ achievement was best under multiple-choice item format and least when exposed to short answer.

Repeated Measures Analysis of Variance on Mean Achievement Scores of Students Exposed to Short-Answer, Multiple-Choice, and True–False Item Formats in STEM.

The results presented in Table 4 show that there is a significant difference in students’ academic achievement as a result of the item format they were exposed to F(1.905,1011)=735.906, p<0.05. Therefore, the results show that there is a
significant difference. Having found out that there is a significant difference, it is necessary to make pairwise comparison to found out where the difference lies, the result of pairwise comparison is shown in Table 5.

From Table 5, it can be seen that there is a significant difference between Multiple choice and True–false, between True–false and Short answer, and between Short answer and Multiple choice. From the values of means in Table 3, it then means that the mean of Multiple choice is significantly higher than that of True–false and that of True–false is significantly higher than Short answer.

**Model elaboration**

The PADA (Presentation, Assimilation, Discussion, and Assessment) Learning/teaching model has achieved good results in Islamic universities in Indonesia. The module included Bridge-in, Objective/Outcome, Pre-assessment, Participatory Learning, Post-assessment, and Summary in learning/teaching model has been a great success as well. The module modes try to strengthen the interaction between students and teachers, increase students’ active participation in classroom, to improve the teaching effect.

The so-called “PADA” learning/teaching mode is a teaching concept first put forward by Zhang Xuexin, professor of psychology in Fudan University. The key to putting forward the concept of “PADA class” is to stimulate students' subjective consciousness of learning in class (Lijuan, 2019). In short, half of the classes will give to the teacher and half to the students. This is different from the traditional teaching and indoctrination class. In the course of classroom teaching and studying activities, students take the initiative to participate in learning, which can reflect students’ subjective learning consciousness. In the process of participation, the way of impartation of knowledge has changed. Students no longer receive information passively as in the past, but gain a certain initiative to explore, talk, and debate. They are no longer passive “listening” and “remembering,” but exploring and expressing opinions independently.

### Table 5  pairwise comparison Analysis

| (I) Formats | (J) Formats | Mean (I–J) | Std. Error | Sig.| 95% Confidence Interval |
|-------------|-------------|------------|------------|-----|------------------------|
|             |             | Lower | Upper |     |       |
| 1 | 2 | -4.242* | .119 | <.001 | -4.528 | -3.956 |
| 3 | 2 | -1.486* | .101 | <.001 | -1.730 | -1.242 |
| 2 | 1 | 4.242* | .119 | <.001 | 3.956 | 4.528 |
| 3 | 1 | 2.756* | .102 | <.001 | 2.512 | 3.000 |
| 3 | 2 | -2.756* | .102 | <.001 | -3.000 | -2.512 |
The status of teachers and students has also changed. In traditional class, teacher is the protagonist, and can decide the completion of the classroom-teaching task alone. In PADA class, students occupy the main position in learning. Teachers changed from “actors” to “directors,” and students changed from “audiences” to “actors.” “PADA class” helps to ignite students’ enthusiasm for learning in class, fully mobilize their brains to think in class, and make full use of the classroom environment in the process of mutual discussion. The effective communication and thinking collision achieve real learning and build a community of teachers and students. “PADA class” can effectively increase students’ interaction and promote team cooperation in class. At the same time, the interaction between teachers and students is also increased. Teachers can join the discussion between student groups at any time. The interaction between teachers and students has been greatly improved than before (Lan 2018). ““PADA Class” does not abandon traditional teaching, but on the premise of ensuring that knowledge can be transferred systematically, accurately, and effectively, combined with the characteristics of discussion-based teaching, highlighting the status of students in classroom teaching. The BOPPPS teaching model originated in Canada. It breaks the classroom into Bridge-in, Objective/Outcome, Pre-assessment, and participatory learning, post-assessment, and summary (Zhaohui and Zhen 2017).

Bridge-in: Teachers can use pictures, videos, stories, questions, hot topics, and other methods to start a lesson. The introduction must be lively and interesting to attract students’ attention and stimulate their curiosity and interest in learning.

Objective/Outcome: Use blackboard writing, PPT, and other methods to present students with specific learning objectives. Learning objectives should include three aspects: cognition, emotion, and skills. Learning objectives should be set according to the analysis of learning conditions, which is clear and in line with the actual situation of students. At the same time, learning goals should be attainable and verifiable. This part is intended to allow students to clarify what goals they want to achieve in the lesson, so they can learn in a targeted manner.

Pre-assessment: Before explaining the new knowledge of this lesson, teachers can use questions and answers, quizzes, anonymous voting, group discussions, and other methods to understand students’ interest in this topic and prior knowledge. Then teachers can adjust the depth and progress of the subsequent teaching content to make the learning objectives and classroom topics more focused.

After the main knowledge including concepts, key points, and difficulties is clarified, students can participate in learning activities in a plentiful and interesting way such as personal reports, group discussions, case studies, role-playing, experiments, storytelling, and solitaire. Through participatory learning activities, students can improve their understanding of knowledge, deepen their impression of knowledge mastery, and improve their interest in learning. Practice shows that the effect of student active participatory learning is far better than passive learning. Furthermore, through the design of this part, students can exercise their expression, communication, and cooperation skills in activities.
Post-assessment: The purpose of post-assessment is to verify and test learning results. After the participatory learning, check the students’ mastery in this lesson by answering questions, quizzes, exercises, operating demonstrations, and reporting. Then teachers can check if the learning objectives achieve and how the teaching effects are (Hongtao, et. al, 2020), which calls post-testing.

Summary: Finally, teachers should make a summary of what we have learned in this lesson to strengthen students’ impression. The teacher can highlight the knowledge points, emphasis, difficulty, and learning objectives of this lesson. Let the students summarize first, the rest people supplement, then the teachers emphasize the key and difficult points. Then the effects are better. At last, teachers can extend and consolidate the effects of this lesson by assigning homework.

The application of PADA model is more suitable for small class, but the university STEM courses sometimes have high number of students in a classroom at the same time.

How to apply the advanced teaching mode effectively to the large class of STEM courses is the main problem we focus on. BOPPPS mode has strict teaching regulations, making it lack of flexibility. This is actually disadvantageous to the promotion and application of the mode. Therefore, in practical application, it needs to be improved according to the characteristics of the course. This paper proposes a new “PADA + BOPPPS” teaching mode, which organically combines them to complement each other’s disadvantages, and thus proposes a new teaching mode. At the same time, we should change the current situation of “teaching-oriented” in university STEM courses, give full play to students’ subjective initiative, and truly realize the “student-centered” and “learning-oriented” innovative classroom.

Discussion

This module motivates and inspires academics to be engaged in an effective learning environment through Social learning. This module successfully integrates the need to produce quality e-learning approaches through the exposure that has been given before, during, and after the course. The use of information technology especially social media application, Microsoft Teams platform, and search of e-materials through Google and other search engines has made the experience and journey of learning in STEM something easy and realistic to achieve in time set by the student her/himself. Dedicated academics are certainly able to interact with students and create effective learning environment in addition to use the appropriate assessment tools.

Overall, it can be concluded that the e-learning can be instilled among academics and students in Islamic universities through the modules that have been built. In addition, the study also proved that the built-in modules used online and monitoring through specific applications and internet were highly beneficial and became a catalyst to participants’ success in e-learning as expected. The positive attitudes and emotions instilled in course participants make them more motivated to be engaged in Social learning environment. Reliance on information technology in R&D in
Higher Education Institutions became very important especially during the Covid-19 pandemic that hit the world since December 2019. It is proposed that this module can be patented and utilized by students and academics from various institutions of higher learning in and outside Indonesia.

Furthermore, the results of the study revealed that there was a significant difference in the mean achievement scores of STEM students exposed to short-answer, multiple-choice, and true/false item formats. The finding of assessment approach agrees with the position of Javid (2014) that the test formats through which the participants were assessed had a significant effect on the scores they receive in the final exam. Javid further posited that there was a significant difference in the performance of students with different test formats.

The findings of this study indicated that STEM students recorded best performance with multiple choice format and least performance with short answer format on exposure to three objective test formats. This could be traced to the fact that students tend to be most favorably disposed to multiple choice format relative to other objective test formats. The mean for short answer format was least probably because the test called for a more demanding task of recalling, while multiple choice called for recognition. The findings of the current study contradict the position of Pradeep et al. (2017) that the performance of students exposed to short-answer type questions was significantly higher than those who were assessed using multiple choice questions. This contradiction may be traced to the peculiarity of the students in the area of study. Additionally, it could be linked to the fact that STEM students are more intellectually mature than those used by Predeep et al. (2018) and more used to multiple choice formats than true–false.

The findings of this study also indicated that the mean for multiple choice is higher than that of true–false even though the guessing factor for true–false is greater than that of multiple choice, but then the test called for a more demanding task of guessing. The finding of the present study agrees with the position of Simbak, et al. (2014) which revealed that both academic year results pointed out that the students got higher marks in multiple choice than true–false.

Conclusion

This study introduced new e-learning module called PADA highly used in Social learning. This module motivates and inspires academics to participate and interact with students through video call learning, LMS, and social media applications. This module successfully integrates the need to adopt a high-quality e-learning approach through the exposure that has been given before, during and after the course. The use of information technology especially social media application, Microsoft Teams platform, and others through Google and other search engines has made the experience and journey of e-learning something easy and realistic to achieve in time set by the students themselves.

The results also revealed that examination bodies, teachers, and school administrators should rely on the use of true–false theme since it does not lead
to unnecessarily high scores due to guessing factor, as people might think. Furthermore, examination bodies such as WAEC, JAMB should keep relying on Multiple choice since it leads to higher scores than other test formats.

**Recommendations for re-using module**

In this module, PADA and BOPPPS teaching modes were combined, which fully embodies the “student-centered” teaching concept.

1. **In the import process,** researcher combines the lead-in and pre-test steps of BOPPPS teaching method flexibly. In this link, original Flash as the carrier to introduce a new lesson with an interesting story was used, which reflects the wisdom of the protagonist and easily arouse students’ empathy. The effect of stimulating students’ interest must be very good.
   
   At the same time, in this story, use the appropriate way that students first discuss and then learn new knowledge. Students analyze how the protagonist’s actions in this story change the probability of the event. Take the above design as a pre-test.
   
   Learning from the PADA learning/teaching method, half of the time is given to teachers to tell stories and make comments, and half of the time is given to students to discuss, answer, share, and exchange.

2. **In the part of participatory learning,** participatory learning and post-test steps in the BOPPPS teaching method were combined. In the part of the practicing, half of the time will be given to the lecturer to analyze the application steps, key points, and background of the total cases. The other half of the time gives to student groups to discuss, answer, share, and exchange. Then students will prove by analyzing the case by the teacher’s comments to sublimate the students’ understanding of the theory. It designs that the students will divide into two teams to complete the test problems and find faults with each other.
   
   This link not only can test the students’ learning effect, but also can strengthen the communication between students, improve the ability of students’ expression and collaboration.

3. **In the expansion of learning,** Module not only introduces the origin and development of knowledge, and more importantly, introduce students to the application of the knowledge learned in real life.

4. **In the summary part,** students can summarize the lesson by themselves. Students discuss in groups and check each other’s deficiencies. Then, the group representatives will summarize and encourage students to share their learning experience and tips. This link exercises students’ advanced abilities.

Through the practice and analysis of different practices in STEM learning, it is believed that teaching innovation should always carry out the concept of “student-centered.” The new teaching method of “PADA+BOPPPS” not only exercises students’ ability to analyze and solve problems, but also strengthens the interaction among students. It cultivates students’ responsibility and communication skills
in a team, strengthens their ability to solve practical problems with mathematical knowledge, and stimulates their interest in active learning.

**Declarations**

**Ethical approval** Not Applicable.

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