Hybrid learning in mathematics education: How can it work?

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Abstract. The aim of the study reported upon in this paper is to investigate what is the potential of hybrid learning in mathematics education, and which factors that are decisive in making it work in the mathematics classroom? An explorative study was conducted at the Department of Mathematics UNNES involving 30 students. consisted of an introduction session, a series of lectures conducted online and offline, and a debriefing session. This leads to the conclusion that factors for the success of hybrid learning in mathematics education include the corresponding material exploiting the learning management system features, regulation, supporting facilities, the role of the lecturer in facilitating the course, and students' perception towards hybrid learning.

1. Introduction

The fourth Industrial Revolution has changed the landscape of educational technology. This revolution is supported by the development of artificial intelligence and physical-virtual systems that make the relationship between humans and machines become more common. This revolution also has an impact on changes in the model of education in the future, called Education 4.0. Nowadays, newcomers have acted as disruptor technologies, such as: Internet of Things (IoT), Mobility, AI, VR/AR, and Automation. Technology has been digitized and has an exponential development acceleration and everything become faster and cheaper. In the field of education, online learning has the potential as a disruptor [1].

To deal with this era of disruption, the use of ICT for distance learning is important to be improved. The development of students' competencies, educators and the development of school facilities and infrastructure needs to be developed with the use of ICT. Currently, communication between computers is common. By utilizing advances in the field of telecommunications and information, the world of education develops an electronic-based learning strategy or better known as e-learning [2]. Infrastructure in the telecommunications sector that supports the implementation of e-learning has been able to be utilized in learning in various regions evenly.

Utilization of ICT for lectures supports the realization of online learning. By paying attention to existing needs, characteristics, situations and conditions, online learning can also be combined with traditional learning, known as hybrid learning [3]. There are various types of models and infrastructure that can be used in the implementation of hybrid learning, so that to determine a suitable model and support for regulations that govern its implementation, a study needs to be carried out. Nowadays, facilities contained in electronic devices provide opportunities for students to share experiences, discuss, and help each other, work together to share text, sound, image, animation, video and combination files. Other social activities can build students' experiences and social attitudes. This has the potential to influence the nature of mathematics education and the concept of mathematics learning [4].

Based on the description above, it is considered very necessary to develop and explore the potential of the implementation of hybrid learning model that are appropriate and in line with the expected and guaranteed quality for mathematics learning. Based on the above background, the main question in this study is: how can hybrid learning models work in mathematics lectures at universities?

2. Theoretical Framework

2.1. Cognitive Theory

In social cognitive theory, a student will gain understanding by observing something both in the social and school environment that will later be affected by his behaviour. Social cognitive theory considers the importance of the ability of the "observer" to display a specific behaviour and the trust it possesses to display the behaviour. This belief is called self-efficacy and this is seen as a critical requirement of behaviour change. This theory is used to study the development of E-learning.

2.2. E-learning

E-learning is instructional content or learning experiences delivered or enabled by electronic technology [3]. Another definition stated that electronic learning (e-learning) is a learning activity that utilizes networks (Internet, LAN, WAN) as a method of delivery, interaction, and facilitation and is supported by various other forms of learning services. There are at least three important things that become requirements in e-learning, namely: (a) learning activities carried out through network (LAN or WAN) utilization; (b) the availability of learning service support that can be used by learning participants, and (c) the availability of tutor service support that can help learning participants when facing difficulties.

In addition to the three conditions above, other requirements can be added, such as: (a) institutions that organize/manage e-learning activities, (b) positive attitudes of students and education staff on computer and internet technology, (c) design a learning system that can be learned/known by each participant in learning, (d) an evaluation system for the learning progress or development of participants, and (e) feedback mechanisms developed by the organizing institution. Another notation related to e-learning is Learning Technology (LT) which is defined as the use of technology to improve teaching, learning and assessment. The LT application includes exercises, tutorials, information retrieval systems, simulations, microworlds, cognitive tools for learning, productivity tools and communication tools.

Some universities in several countries provide several alternative models of learning activities/lectures to their students [5]. The goal is that students can flexibly manage their lecture activities in accordance with the time and other activities of students. There are three alternative models of learning activities that students can choose, namely: (1) fully face-to-face (conventional), (2) partly face-to-face and partly through the internet (hybrid learning), or even (3) fully via the internet.

2.3. Hybrid learning

Hybrid learning combines the best features of traditional schooling with the advantages of online learning to deliver personalized, differentiated instruction across a group of learners [3]. Students in formal hybrid learning educational programs learn online part of the time, yet have the benefit of face-to-face instruction and supervision to maximize their learning and to best fit their own needs. Hybrid learning combines the best features of traditional schools with the advantages offered by online learning to provide personalized and different instruction across groups of learners. Students in hybrid learning programs can learn online and still have the opportunity to face-to-face learning to maximize their learning according to their own needs [6].

A research about schools and hybrid learning programs [1] produce findings that most hybrid programs can be classified into four models, namely: Rotation, Flex, A La Carte, and / or Enriched Virtual.

2.4. Rotation Model. For each subject, students rotate either on a fixed schedule or at the teacher's discretion among the learning modalities with one of them being online learning.

2.5. Flex Model. For each subject, online learning becomes important in the learning process and directs students to offline activities.

2.6. A La Carte Model. Subjects attended by students are fully done online to provide other experiences to students in face-to-face learning.

2.7. Enriched Virtual Model. Students are required to conduct face-to-face learning sessions with teachers and then be free to complete their remaining subject matter online.

2.8. Utilization of technology in mathematics learning

Learning is the development of new knowledge, skills, or attitudes as individual interactions with information and the environment [6]. The learning environment includes physical facilities, psychological atmosphere, instructional technology, media, and methods. In a didactic situation in mathematics, individual learners build new mathematical knowledge in a learning environment facilitated by the teacher [7]. As a facilitator in the learning process, the teacher designs and gives instructions to learners. Instruction is a set of non-learning events designed to support the internal learning process. These instructions are needed to facilitate the learning process by managing information and learning environments [8]. The environment is not only a place for teaching to take place, but also the technology, methods and media needed to convey information and guide learners in the learning process.

In this process, technology also plays a role. Technology is an important tool for learning mathematics in the 21st century which has the potential to be a fundamental tool for learning mathematics and stimulating the thinking process and all schools must ensure that all their students have access to technology. Technology has the potential to support student activity in learning mathematics literacy [9]. However, besides the use of technology, the effectiveness of using technology in teaching and learning mathematics in schools also needs to be considered. Simply using technology is not enough: technology must be properly integrated with work techniques, curriculum, learning and mathematical assessment [10]. It is important to consider when and how technology can support teaching and learning appropriately and effectively.

3. Methods

To address the "how can" research question with regard to exploring the potential of the implementation of hybrid learning model for mathematics teaching and learning process at the university, this study used a explorative research approach [11]. An online learning system were designed with corresponding teaching and learning activities, several offline learning activities were also planned, and a sequence of pilots was set up. As a pilot study, this study was conducted in the Department of Mathematics Universitas Negeri Semarang, Indonesia, and involved 30 students and one lecturer of Geometry. This research was conducted in one introductory phase and in three subsequent phases (prototypical design, a small-scale field experiment, and a large-scale experiment). In all pilots, the researchers conducted observations as participating researchers. Notes were made and data was collected, then a debriefing session was conducted afterward. Analyses began with the organization, annotation, and description of the data.

4. Results and Discussion

The research was conducted in 2017-2018. This research began with a preliminary phase to define the specification procedure and to develop technical requirements as a foundation and guideline for designing the system. Based on a theoretical framework, in the next phase, the online learning system were designed, and the learning activities were formulated. The lecture materials, both for online and

offline learning activities, were created by lecturer. They were then validated and evaluated by experts. Furthermore, the small-scale and large-scale field experiments consisted of an orientation session, a hybrid learning run, and a debriefing session. A series of pilots were carried out in this phase.

In the design phase of the study, the Learning Management System (LMS) was designed. This can be accessed through http://courses.mathe.id with the given accounts. This system enables the uploading of lecture materials (texts, audio, picture, video, etc.) created by lecturer. Students get the opportunity to access and upload content or submit assignments. Online discussions both privately and generally between students and students or between students and lecturers can be carried out in this system. In this phase, an offline learning activities role was designed in this phase as well. The system displays the learning materials, discussion forum, chat, quiz, assignment, and test which can be accessed and done by students. Lecturer can access information about activities that occur and can carry out assessment through the system. Lecture materials can be in the form of texts, audio, pictures, videos, or other forms. Figure 1 shows examples of lecture material: the explanation video about the process of determining distance in space.

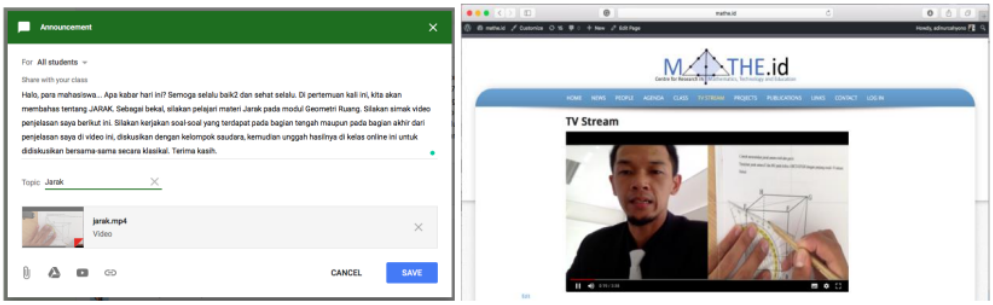

Figure 1. The explanation video about the process of determining distance in space.

The materials have passed the evaluation process through validation by experts and the simulation phase involving a small group of students and lecturers and have been deemed eligible for use in the next phase. The large-scale field experimental phase was conducted in 2018 involving 30 students and one lecture. Lectures are conducted face-to-face in regular classes (10 meetings) and also through an online system (4 meetings). Midterm exams and final exams were conducted offline excluding the time of these meetings. In addition, assignments and online discussions were carried out all the time and not only during meetings. Lecturers give lectures, explain the material, give treads on discussion forums. Then students follow lecturer's explanations, give answers and comment on other students' answers, and submit assignments. The lecturer facilitates the lecture process, corrects opinions, and guides students to draw conclusions. Lecturers also provide evaluations and assessments as shown in Figure 2.

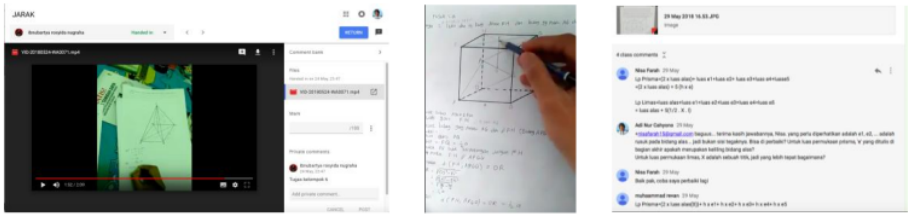

Figure 2. Examples of students' work and students-lecturer discussion.

The findings indicated that the activities ran smoothly, the system worked well, and the rules and goals of the activity proved to be comprehensible. Lecture and students were enthusiastic about participating in the activities and provided a great deal of useful feedback. Lecturer reported that they had been helped by the use of the system to facilitate the lecture process. The open-ended questions generate student perceptions. An example of student's response: *"I was able to repeat the explanation and discussion result several times. Thus, I understood and learned better. It was good for me."* The full report on student perceptions is presented in Table 1.

Table 1. Student perceptions about the implementation of hybrid learning

Items	**Score (1-5)**
easy to learn the topic using this system	4,30
learn the topic better using this method compared to textbook	3,87
easy to visualize the important concepts	4,03
able to analyse better	3,96
appreciate on learning integration	4,17
find that mathematics online learning is interesting	4,36

As a serious mathematics educational program, the main focus of this activity is to support students in constructing their own mathematical knowledge. This program was designed to offer students the opportunity to learn mathematics, both in offline and online situations. There is a significant increase (p – value 0.00) in the means of the pretest and posttest, from 5.08 to 9.00. Majority of the students (90%) has achieved the learning completeness that has been set on the topic for the lecture.

The findings show that the features of the system used need to be exploited. For example, explaining the process of determining the distance in the space is not enough just by displaying images or text. This requires an interactive illustration to discuss the process. Therefore, video features and live streaming are seen as one of the features that are suitable for use here. Some other material will match other features, so the determination of features and strategies is adjusted to the conditions and characteristics of the material to be discussed in the lecture on the topic. Different study programs will also be different strategies and features that are suitable for use, even in one subject, they are also varied. The online resource that can be used contains a wide variety of content, such as: classroom videos, instructional videos, animations, simulations, games, online modules, quiz, video conferences, discussion forums, assignments, etc.

In addition to features, the available facilities will also affect the implementation of the hybrid learning lectures. This facility is like: internet connection, ownership of devices by students and lecturers, and systems developed by the university. The attitude of students and lecturers is one of the important factors in the course of hybrid learning at universities. The role of the lecture in facilitating the online course is not easy, and it is important to be mastered by the lecturer in running hybrid learning. Skills and knowledge in the ICT field are other important factors of implementing hybrid learning. In the university level, the prevailing regulations also have a lot of influence on the implementation of hybrid learning.

5. Conclusion

The result leads to the conclusion that factors for the success of hybrid learning in mathematics education include the corresponding material exploiting the learning management system features, regulation, supporting facilities, the role of the lecturer in facilitating the course, and students' perception towards hybrid learning. The findings also show that the setting of this learning environment has a positive impact on student learning outcomes in geometry course. Further research studies are essential for project development and implementation in other course and other study program facing different situations.

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