Synchronous and Asynchronous Setting in Online Learning to Increase Vocational Students' Motivation in Mathematics: Comparative Studies

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Abstract

This study aimed to investigate and compare the factors that influence students' motivation to learn mathematics during synchronous and asynchronous learning. Although many studies related to these two learning models have been carried out, there is still little research on the analysis related to the mathematics learning motivation of vocational program students during the Covid-19 pandemic. The study involved 109 students (Diploma III and Diploma IV) of vocational universities in Bali who were randomly selected and given two different treatments on the same sample. The primary data collection instrument was arranged in a closed-ended questionnaire. Data were analyzed by using the two-sample paired Wilcoxon Signed Rank Test. The results showed that the motivation to learn mathematics for students in the vocational program during asynchronous online learning tended to be better than when the learning process was conducted synchronously. Based on the interviews conducted, there are several causes related to connectivity constraints, the flexibility of study time and discussion, and ease of access to learning resources.

Abstrak

Penelitian ini bertujuan untuk menginvestigasi dan membandingkan faktor-faktor yang mempengaruhi motivasi belajar matematika siswa selama mengikuti pembelajaran synchronous dan asynchronous. Meskipun studi terkait kedua model pembelajaran ini telah banyak dilakukan, analisis terkait motivasi belajar matematika mahasiswa program vokasi di masa pandemi Covid-19 masih sedikit ditemukan. Penelitian melibatkan 109 mahasiswa (Diploma III dan Diploma IV) perguruan tinggi vokasi di Bali yang dipilih secara acak dan diberikan dua perlakuan berbeda pada sampel yang sama. Instrumen pengumpulan data primer disusun dalam closed-ended questionnaire. Data dianalisis dengan uji dua sampel berpasangan Wilcoxon Signed Rank Test. Hasil penelitian menunjukan bahwa motivasi belajar matematika mahasiswa program vokasi selama mengikuti pembelajaran daring secara asynchronous cenderung lebih baik dibandingkan dengan synchronous. Berdasarkan wawancara yang dilakukan terdapat beberapa penyebab yang terkait dengan kendala konektivitas, fleksibilitas waktu belajar dan diskusi, serta kemudahan dalam akses sumber belajar.

Keywords: *Pandemic; Synchronous; Asynchronous; Mathematics Learning Motivation; Vocational Students*

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INTRODUCTION

Mathematics learning for vocational students is directed at implementing the concepts taught in class (realistic mathematics-based). Through this approach, abstract mathematical objects are represented by concrete objects as a bridge for the knowledge that students already have (Saleh et al., 2018). Students also find it easier to understand mathematical concepts by looking for links between the material being studied and common problems (Özkaya & Yetim, 2017). U.S. (2012) stated that through this approach students will feel learning as a personal experience, not the experience of others that they have not experienced. To bridge the abstraction of mathematical concepts with their realistic application in the field, intensive assistance in the classroom is needed to know when and how to apply the concepts learned in the industry.

The vocational education program, as already mentioned, is an education system designed to prepare certain knowledge, skills, and competencies for students to enter the world of work, industry, or trade (Cedefop, 2017). Alloway et al. (2013) stated that the characteristics of students who take part in learning at vocational education institutions are different in terms of age, educational background, and cognitive abilities, especially memory performance. Learning for vocational program students is focused on the development and application of acquired skills (Shrestha, 2016). Therefore, the teaching materials used are designed in such a way that the resulting competencies can be applied and developed according to market needs (Candiasa et al., 2019).

Student success in learning mathematics is influenced by internal and external factors. One of them is learning motivation (Oktaverina & Nashori H. Fuad,

2015). From previous research, it was found that students with high learning motivation obtained good learning outcomes (Simanjuntak et al., 2020). This indicates that the increase in students' motivation to learn mathematics is followed by an increase in academic achievement.

The SARS-CoV-2 Coronavirus pandemic has converted conventional teaching and learning patterns (face to face interaction) into a distance learning model. Digitization of mathematics education and online learning is considered the best solution in the era of the global pandemic (Mulenga & Marbán, 2020). Regarding the condition where students are not allowed to learn directly in class, the alternative is to change the traditional education pattern into the form of online learning (Basilaia & Kvavadze, 2020). This transformation of the learning system brings new challenges to all levels of education, especially vocational education.

The change of the learning system into a virtual classroom from home has forced mentoring and learning to be done online through the support of existing technology. The technology referred to here is the technology that changes learning settings and the way teachers facilitate their classroom interactions and activities (Diao & Hedberg, 2020). Furthermore, the concept of an online learning environment requires appropriate e-learning media and provides easy access and installation anywhere and anytime (Risniawati et al., 2020; Rahmadani et al., 2020). Several previous studies have demonstrated the effectiveness of virtual classes in providing meaningful learning experiences (Perdana et al., 2020; Sumardi & Muamaroh, 2020; Leontyeva, 2018). Furthermore, it is known that this also applies to learning mathematics. Apsari et al. (2020) found that distance mathematics classes can still produce good quality even though they are carried

out using a simple, cost-effective application.

In general, there are two types of distance learning, namely synchronous and asynchronous (Shahabadi & Uplane, 2015). Synchronous learning occurs when lecturers and students interact at the same time, on the other hand, asynchronous class forms involve students in exchanging ideas or information without any involvement at the same time (Fitriyana et al., 2020). In the synchronous course system, students must take direct online classes and interact directly (teleconferences) with lecturers. This type allows students from anywhere to participate at a predetermined time. Applications used to support the implementation of synchronous learning are generally video conferencing platforms such as Zoom, Google Meet, and Skype. From previous research, it is known that the integration of video conferencing in virtual mathematics learning provides an opportunity for lecturers and students to conduct more meaningful mathematics learning and allows interaction outside the boundaries of the general class (Johnson et al., 2016). Learning with synchronous online system courses is felt to be more interactive because it allows direct feedback to students (Daft & Lengel, 1986). Communication in synchronous learning is also useful for supporting learning with additional tasks, strengthening social interactions, and exchanging information with simpler complexities (Hrastinski, 2007). Furthermore, previous studies have found that synchronous learning affects students' thinking and learning creativity (Kuo, 2016).

In the asynchronous learning model, students do not have to attend lectures in real-time (live). Lecturers can provide digital content within a certain period and students can adjust the time to access learning materials. These digital teaching materials have the potential to make students independent because they can be seen anywhere and anytime in distance learning (Indariani et al., 2019). Interaction through asynchronous patterns allows students to take online classes at any time, think of ideas and formulate or revise answers when needed (Palloff & Pratt, 1999; Tuovinen, 2000). Thus, students have more time to reflect on learning (Hansen et al., 1999) because discussions are generally scheduled for the entire material or for a longer period of time. Virtual class interaction in asynchronous learning is generally done through discussion boards using Google Classroom. Abidin & Saputro (2020) in their research stated that the use of this platform has good potential in supporting learning because it allows teachers to design virtual classes, send assignments, feedback, and see students' answers.

Basically, synchronous and asynchronous models in online learning have specific roles and optimum conditions depending on the needs of students (Hrastinski, 2007). However, currently, there is no research about forms of synchronous and asynchronous online mathematics learning that can recommend which form is more motivating for vocational program students. Reflecting on the conditions mentioned earlier, this research is an affiliate of research related to online mathematics learning and the use of application platforms in learning. In particular, the comparative nature in this study aims to provide information for teachers and researchers regarding which virtual learning system affects students' mathematics learning motivation, especially vocational program students.

Table 1. Blueprint of Motivational Instruments for Learning Mathematics for Vocational Students

Dimensions	Indicators
Internal Motivation	There is a desire to succeed
	There is encouragement and need in learning
	There are hopes and aspirations for the future
External Motivation	There is appreciation in learning
	There are interesting activities in learning
	There is a conducive learning environment that allows students to learn well

METHODS

The study conducted in this research aimed to compare the mathematics learning motivation of vocational students during synchronous and asynchronous learning. The research was conducted in online lectures during the Covid-19 pandemic. The sample involved was 109 students (Diploma III and Diploma IV) of vocational universities in Bali for the academic year 2020/2021 who were randomly selected and given two different treatments on the same sample.

Primary data were collected through questionnaires after the lectures on Statistics, Discrete Mathematics, and Matrix Linear Algebra were conducted. The selection of these courses was based on the results of a questionnaire which stated that the three courses were difficult to understand during online learning. The primary data collection instrument was arranged in the form of a closed-ended questionnaire. The instrument in this study refers to the theory of learning motivation and analysis in the field of education which refers to two dimensions of learning motivation. These two dimensions are further described in 6 indicators which are then developed into 25 statement items using a Likert scale (Uno, 2006). The questionnaire was then reviewed by 3 education experts in a focus group discussion and tested for validity and reliability. The blueprint of the questionnaire used is presented in Table 1.

The statistical test used is a nonparametric test. The mathematics learning motivation data obtained in the sample were analyzed and then compared quantitatively using the two-sample paired Wilcoxon Signed Rank Test (Sugiyono, 2019; Supardi, 2019). The paired data Wilcoxon test examines the median differences in paired data. Paired data means that the values in the two groups tested are connected naturally or come from individuals who are measured more than once (Bland, 1995). This test is carried out based on the magnitude of the difference in pairs of observations. The assumption of a normal distribution is not applied to the Wilcoxon Signed Rank Test because it is carried out based on rank order and does not calculate the difference in the original data. However, it is necessary to assume that the distribution of the data difference is symmetrical (Conover, 1980). Several assumptions used in this study include 1) paired data or in the same population; 2) each data pair is selected randomly and independently, and 3) the data is measured on an ordinal minimum scale.

RESULTS AND DISCUSSION

Results

Validity and Reliability Test of the Questionnaire

Before being used as a research instrument, the questionnaire used was

Table 2. r count, Validity and Cronbach's Alpha Value

Item Statement	Synchronous Online Courses		Asynchronous Online Courses	
	r count	Validity	r count	Validity
Item 1	0,624	Valid	0,653	Valid
Item 2	0,606	Valid	0,599	Valid
Item 3	0,552	Valid	0,586	Valid
Item 4	0,722	Valid	0,628	Valid
Item 5	0,637	Valid	0,693	Valid
Item 6	0,678	Valid	0,475	Valid
Item 7	0,658	Valid	0,771	Valid
Item 8	0,700	Valid	0,633	Valid
Item 9	0,454	Valid	0,371	Valid
Item 11	0,571	Valid	0,494	Valid
Item 12	0,537	Valid	0,608	Valid
Item 14	0,696	Valid	0,641	Valid
Item 15	0,542	Valid	0,545	Valid
Item 16	0,729	Valid	0,727	Valid
Item 17	0,477	Valid	0,394	Valid
Item 18	0,367	Valid	0,465	Valid
Item 19	0,432	Valid	0,472	Valid
Item 20	0,391	Valid	0,398	Valid
Item 21	0,683	Valid	0,592	Valid
Item 23	0,529	Valid	0,468	Valid
Item 24	0,616	Valid	0,575	Valid

Cronbach's Alpha questionnaire on Synchronous Online Courses = 0,921 (reliable)
Cronbach's Alpha questionnaire on Asynchronous Online Courses = 0,898 (reliable)

tested for validity and reliability. This test involved 30 respondents from Bali State Polytechnic students. Each statement item is declared valid if the calculated r-value is greater than the r table with n-2 degrees of freedom (r table value = 0.361). Furthermore, the questionnaire is declared reliable if the Cronbach's Alpha value is greater than 0.6.

Based on the validity test of the first stage of the questionnaire, it was obtained that there were four statement items that had an r-count value of less than 0.361 (question items 10, 13, 22, and 25) with an r-count value of -0.557; -0.314; 0.141; and 0.045 (questionnaire for students' motivation to learn mathematics on synchronous online courses) and -0.488; -0.240; 0.030; and 0.200 (questionnaire for students' mathematics learning motivation on asynchronous online courses). For this reason, the four statement items were not included in the subsequent analysis. Data related to r count, validity, and Cronbach's Alpha value which was carried out after removing the four invalid statement items, are presented in the Table 2.

Paired Two-Sample Test

Motivation comparison to learn math for students during the synchronous and asynchronous online learning courses was conducted by a paired two-sample test with a one-way right hypothesis as follows:

$H_0 : \mu_1 \le \mu_2$ (The Students' motivation to learn mathematics during synchronous online courses is less than or equal to students' motivation to learn mathematics during asynchronous online courses)

$H_1 : \mu_1 > \mu_2$ (The students' motivation to learn mathematics during synchronous online courses is greater than the

motivation to learn mathematics during asynchronous online courses)

The statistical test used was a paired two-sample t-test with an alpha (error rate) of 5%. However, before the t-test analysis was conducted, a test was conducted on the assumption of normality of the data difference between students' motivation to learn mathematics during synchronous and asynchronous learning. Data normality analysis was performed using the Kolmogorov-Smirnov test or the Shapiro-Wilk test. The data is declared normally distributed if the Sig value is more than 0.05. The results of the normality test of the difference data conducted using the Kolmogorov-Smirnov and Shapiro-Wilk tests are presented in the Table 3.

Table 3. Data Normality Test

Vari-abel	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
dif-fer-ence	0,160	109	0,000	0,922	109	0,000

The data presented in the table above shows that the Sig value of the Kolmogorov Smirnov and Shapiro-Wilk tests is 0.000. This value is less than 0.05 so that based on the analysis, it can be concluded that the assumption of normality is not met. For this reason, the analysis was continued with the nonparametric Wilcoxon Signed Rank Test.

Table 4 shows the results of the tests carried out with the Wilcoxon Signed Rank Test. The data shown in the table indicates that the Z value of the Wilcoxon Signed Rank Test is -1.335 with a significance value for the two-way hypothesis of 0.182. Rejection of H_0 for the one-way right hypothesis is carried out if the calculated Z value is greater than the Z table value. Furthermore, the Z table value for 5% alpha and one-way hypothesis is 1.65.

When compared with the Z count which is -1.335, it can be stated that the Z count < Z table. Thus, based on the analysis carried out, there is not enough evidence to reject H_0. The conclusion obtained is that the motivation to learn mathematics of vocational students while participating in a synchronous course is less than or equal to the motivation to learn mathematics of students who take the asynchronous online course.

Table 4. Wilcoxon Signed-Rank Test

	Students' motivation to learn mathematics during synchronous learning - Students' motivation to learn mathematics during asynchronous learning
Z	-1,335
Asymp. Sig. (2-tailed)	0,182

Discussion

The results of hypothesis testing show that students' motivation to learn mathematics during asynchronous online learning is greater than or equal to synchronous learning. This phenomenon indicates the student's response following the asynchronous vocational program lectures in mathematics with Google Classroom tends to be better than the synchronous learning platform such as Zoom, Google Meet, and Skype. This is due to the following descriptions.

In terms of process, synchronous virtual learning requires students to take part in a live teleconference. This model is generally carried out with discussions and lectures. Although it provides a new experience for continuing to attend classes during the pandemic, synchronous learning cannot be followed by students who are constrained by signals. This is supported by previous research which states that internet connection is one of the

Fragment 1

Student₁ : *Learning mathematics by teleconference in my opinion can be an alternative to offline lectures, it's just that often I can't follow the whole class because of internet connection problems. The quality of sound and video learning during teleconferences is often an obstacle during class and when interacting with friends.*

Student₂ : *Student participation in lectures with Zoom, Google Meet, and Skype is lacking. The class did go on as usual, but it still didn't feel the same. Discussions cannot be carried out freely with friends as I did during offline lectures in class.*

main obstacles for students in interacting (Muhametjanova & Akmatbekova, 2019; Muhametjanova & Cagiltay, 2016). Constraints related to classroom interaction during synchronous learning were also found by Wang et al. (2018). Furthermore, Karaman et al. (2013) found that synchronous virtual classes require planning, preparation with interactive activities and good technical support. If this is not fulfilled, multi-way communication between lecturers and students cannot be carried out optimally. Interviews related to these conditions are presented in the following fragment 1.

The above conditions are different from the asynchronous model which does not involve live interaction between lecturers and students. The form of asynchronous learning provides flexibility in time, methods, and flexibility in how to learn for students without having to be constrained by voice connections and video quality. Students can download mathematics learning videos presented

on the asynchronous learning platforms and watch the video tutorials for free. Kusumaningrum & Wijayanto (2020) in their research stated that online lectures are effective if there are learning videos that contain detailed explanations of the material. Several previous studies have shown the effectiveness of using learning videos in mathematics classes (D. M. Apsari et al., 2018; Aris et al., 2017).

In terms of process, this is the first time for vocational program students to follow the virtual classroom for learning during the pandemic. This makes offline learning schemes such as practicals, workshops, and internships in industry and the world of work difficult to do. As an alternative, students adjust the process by doing independent practice through video tutorials that are stored during asynchronous learning. Furthermore, the study in this research found that vocational program students better understand the application of the concepts they learn. If there are difficulties or errors in

Fragment 2

Student₃ : *Because I can't do practical lectures and workshops on campus, I can still learn by watching video tutorials posted by the lecturers. I can see the math material being practiced and re-study it or discuss it through the learning platform chat room. Since it is not limited by time, I can watch it any time. When it is clear, I can practice independently from home. Of course still with guidance from online lecturers.*

Student₄ : *This is the first time I did practical lectures from home because of health protocol reasons. However, with video tutorials that can be downloaded and saved, I can follow step by step practicum and find out how I will use mathematical concepts when I study internships in the industry later. In addition, learning mathematics no longer has to depend on smooth connections and internet quotas.*

Fragment 3

Student$_5$: *Before entering the virtual meeting room, I can discuss assignments and materials first with my friends anytime both online and offline (group discussion). This makes me more prepared to study and dare to answer the lecturer's questions because the points that I will communicate have been discussed first.*

understanding the material, they can watch the video tutorial again and study it repeatedly. Excerpts from interviews that support this statement are presented in the following fragment 2.

As mentioned earlier, in the asynchronous learning model, students can do a repetition of learning content. This feature provides enough time for students to prepare lecture materials, formulate thoughts and review the understanding and difficulties obtained. Students can manage their time in doing assignments according to the schedule and time they have. Furthermore, while participating in asynchronous learning, students have more time to discuss the material with their peers before entering the class discussion. This makes this type of virtual learning better because students already have a point of view and an outline of the material to be discussed. This is not found in synchronous mathematics learning. In addition to this, students can also analyze and observe the relationship between abstract mathematical concepts and their realistic applications in more depth. This form of virtual learning strengthens the relationship between students' prior knowledge and new knowledge (Lin, H. S., Hong, Z. R., & Lawrenz, 2012).

The way students communicate their written ideas through discussion boards while solving math problems is more structured than when they participate in synchronous learning. This finding is supported by previous research which shows that students' understanding of concepts and attitudes after carrying out discussions in asynchronous learning is better than when discussing

synchronously (Yulia Prawestri et al., 2020). In a study conducted by Özyurt & Özyurt (2013), it was found that discussions in asynchronous forums can eliminate errors and produce important learning outputs. Students are more enthusiastic, more prepared in communicating their understanding, and motivated in discussions with their group mates. This happens because of the flexibility of time that students have where they can discuss first before communicating their understanding to the lecturer. Fragment 3 below shows excerpts from interviews that support this.

This is different from the results of previous studies which stated that the integration of asynchronous systems in learning was not optimal in class discussions because students did not meet directly with lecturers and students lacked understanding of the lecture material (Rahmawati et al., 2020).

Students also can look for other related materials to support their prior knowledge, which is difficult to do in synchronous learning settings. Asynchronous virtual space directs learning into the concept of self-paced, independent, and student-oriented learning (Murphy, E., Rodríguez-Manzanares, M. A., & Barbour, 2011). This is also supported by previous research which stated that mastery of mathematics (concept understanding, procedural fluency, strategic competence, adaptive reasoning, productive disposition) and communication skills (clarification, suggestion) are significantly influenced by this form of learning (Sudiarta et al., 2018).

CONCLUSIONS

After a series of trials and analyses, we can conclude that there are differences in motivation to learn mathematics in virtual settings for students of the vocational program during the Covid -19 pandemic. From the results of the analysis, it was found that the students' motivation to learn mathematics by using synchronous learning was smaller or equal to the motivation to learn in a virtual class asynchronously. Based on the interviews conducted, there are several causes, among others, related to signal problems during teleconferences (voice and video), flexibility in learning time, flexibility in discussing which has implications for the structure of ideas communicated, and the availability of learning resources that can be stored and accessed, anytime and anywhere through the discussion board platform.

Research related to the mathematics learning motivation of vocational students in this study is limited to internal and external motivation which is translated into six indicators. To gain a more comprehensive understanding, this study recommends further analysis related to differences in achievement and student learning activities in mathematics as a source of continuous reference for research related to synchronous and asynchronous learning.

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