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Blended online learning: Students' perception and its effect on learning outcomes abstract algebra

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Abstract

In the current digital era, the implementation of blended online learning faces challenges in understanding students' perceptions and its impact on learning outcomes, particularly in Abstract Algebra. This issue is crucial to investigate, as the shift in teaching methods can influence the comprehension of complex algebraic concepts. This research aims to investigate students' perceptions and learning outcomes in abstract algebra courses of blended and asynchronous online learning. The research method used was quasi-experiment. The subject of 27 students is available without being randomly selected. Research instruments using questionnaires and tests. The test consists of eight essay questions. The questionnaire includes 27 closed-ended questions and six open-ended questions. The results showed that students perceived Abstract Algebra subjects as difficult or very difficult. Most students needed help to study the module due to material difficulty thoroughly. In addition, asynchronous online learning is ineffective compared to blended online learning. All students wanted the tutorial asynchronous and synchronous combined (blended online learning). Most students carry out online learning at home using a smartphone device. Students who use blended online learning obtain significantly higher learning outcomes than students who only take it asynchronously.

Keywords:
Algebra abstract, Asynchronous and synchronous, Blended online learning, Learning outcomes, Student perceptions

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1. INTRODUCTION

Open University majors in a distance learning program to offer various learning services such as face-to-face, asynchronous online, synchronous online, radio, and TV tutorials. The implementation of face-to-face tutorials requires a minimum of 20 students, while TV and radio tutorials accommodate more students and provide extra learning material. Meanwhile, asynchronous online learning uses the LMS Moodle with several features, including an introduction or general section, material contents, discussions, and assignments section. The general section contains introductions between tutors and students, students and students, explaining the competencies that students are expected to master by the end of the course, activities carried out during the session, and information on the assessment system. The material content from the module might be considered difficult for students and any additional material not in the module. In the discussion section, students write what has been learned from the material to help them master the content. Furthermore, assignments are given to evaluate students' mastery of the competencies to be achieved in a course.

Mathematics Education is one of the study programs at Open University that offers a course in abstract algebra. According to Fadillah and Jamilah (2016) and Agustyaningrum et al. (2020), abstract algebra an essential element of mathematics courses. In many countries, abstract algebra is an important part of the mathematics curriculum at the university level, often taught in pure and applied mathematics programs. Abstract algebra is part of modern algebra, which needs thinking with a high level of abstraction. This course involves the students' deductive, logical, and systematic reasoning power (Yuniati, 2014). With the development of science and computing, this course can also be applied to computer science, physics, chemistry, data communication, coding theory applications, and cryptography (Judson, 2020). This course is fundamental to accessing higher mathematics levels (Arikan et al., 2015). However, many researchers have reported the difficulties faced by students and teachers in learning Abstract Algebra (Fukawa-Connelly, 2007; Kontorovich & Zazkis, 2017). Open University is no exception, as evidenced by the complaints of students who have challenges understanding the material regarding asynchronous online learning. Furthermore, the abstract algebra course is abstract and closely related to analysis and evidence.

Open University facilitates students from various regions who wish to study through online learning. The implementation of online learning at Open University is 100% asynchronous and 20-30% synchronous. However, many studies have shown various weaknesses concerning asynchronous online learning (Borba et al., 2016; Ene & Upton, 2018; Hung et al., 2020; Smith & Suzuki, 2015). The monotonous course content and the presentation in PDF or slides are considered unattractive to students. Furthermore, the lecturer does not give a closing statement at the end of each discussion, which leads to varied conclusions. The students also do not immediately get feedback from the lecturer when they experience problems. Lack of socialization among students makes them feel they are learning alone without friends and the help of lecturers (Batmang et al., 2021; Ebner & Gegenfurtner, 2019). Students expressed their desire for variations in tutorial presentations, including adding a video in a PowerPoint or videos showing the lecturer teaching. Open

University is replacing face-to-face tutorials with synchronous online, also known as webinar tutorials. The webinar is one of the tutorials in the synchronous network, where there can be direct communication between tutors and students online. Open University's webinar trial tutorials are currently limited to certain subjects, considering the internet network unavailability in some regions.

The advantages of online learning over real classroom learning include flexibility in time, where students can learn anytime and anywhere, access to a wide range of learning resources on the internet, savings on transportation costs since there is no need to travel to a location, and the development of technological skills through the use of digital platforms. Students in rural areas with unstable internet connections usually go to places with good internet access, such as near urban areas, during lectures. Research on asynchronous and synchronous online learning has been conducted (Buxton, 2014). Asynchronous tutorials are considered superior to synchronous because of assignment collection flexibility. Likewise, synchronous tutorials have various merits, including socialization or direct communication and close contact among the students themselves and between students and lecturers. Additionally, through synchronous tutorials, students obtain immediate feedback from lecturers regarding difficult materials, which avoids long waits for answers. Also, asynchronous and synchronous tutorials are cost-efficient and can be conducted by many people (Nguyen, 2015). Furthermore, each lesson supports a different goal. Synchronous online learning increases arousal and motivation, while asynchronous online learning increases the ability to process information. Synchronous online learning highly promotes individual participation, while asynchronous online learning is more supportive of cognitive participation.

Hung et al. (2020) mentioned the weaknesses of the two online learning systems. Asynchronous online learning is boring and monotonous since materials and discussions are only provided in PDF or slide form. The lecturer does not offer closing remarks at the end of each debate, which leads to varied conclusions among the students. Synchronous online learning has its fair share of challenges, including a lack of internet when learning via Zoom or Google Classroom, which renders it ineffective. Furthermore, not all students have Android phones, implying that only the students with the required devices can attend the lectures (Batmang et al., 2021). Suggestions from previous research include integrating the two online learning systems for better results. The combination of these two types of online learning will enable tutors and students to exchange information, collaborate on work, and get to know each other (Amiti, 2020; Yamagata-lynch, 2014). Research has also been conducted regarding blended learning, especially the combination of face-to-face and asynchronous online learning (Bahri et al., 2021; Darma et al., 2019; Lin et al., 2017; Sumarmi et al., 2021; Zubaidi & Jaber, 2019). Meanwhile, Hung et al. (2020) researched face-to-face, synchronous, and asynchronous blended learning. They concluded blended learning is more effective than face-to-face or asynchronous online learning. However, this result contradicts that of Pakhomova et al. (2016), which observed that students who learn using blended learning are lower than students who use face-to-face learning.

Research related to online, blended learning (a combination of asynchronous and synchronous online learning) was conducted by Yamagata-lynch (2014). Further study

regarding blended online learning has occurred in the wake of the COVID-19 pandemic (Moorhouse & Wong, 2022; Rigo & Mikuš, 2021). However, blended studies on abstract algebra courses have not been found online. Yamagata-lynch (2014) conducted research related to online learning environment courses. Moorhouse and Wong (2022) researched English teachers, while Rigo and Mikuš (2021) conducted research related to English courses. Therefore, this research aims to implement Online Abstract Algebra learning using asynchronous and synchronous methods at Open University. The study focuses on student perceptions of the blended online learning process and its effect on learning outcomes compared to asynchronous online learning. The novelty of this research was combining asynchronous online learning using LMS Moodle and synchronous learning using Microsoft Teams for the abstract algebra course.

This research aims to investigated students' perceptions of the asynchronous online learning implemented through the LMS Moodle and synchronous tutorials through Microsoft Teams and its relation to learning outcomes in Abstract Algebra courses at Open University, Indonesia. This research is significant considering that the learning system at Open University for the Mathematics Education study program is all conducted online. Generally, Open University adopts the asynchronous method in online learning, which has not given good results, especially in improving students' performance in abstract algebra courses. Open University can use the results to enhance tutorial implementation and students' learning outcomes. This research provides insights into online mathematics learning, including a comparative analysis of synchronous and asynchronous online learning. Additionally, it explores the benefits of combined online learning for abstract subjects, such as Abstract Algebra courses, which can be challenging to students. It also provides an alternative to Abstract Algebra lecturers to make it easier for students to understand complex concepts using a combination of synchronous and asynchronous online learning.

2. METHOD

2.1. Research Design

This study used a quasi-experimental design with a posttest-only control. A posttest is carried out to obtain student learning outcomes. The quasi-experimental research was conducted because the subjects selected were those who were enrolled in abstract algebra courses, and their numbers were limited, so random selection of subjects was not performed. The research subjects were grouped in two classes, not randomly, because only two classes were available in abstract algebra courses at Open University Indonesia. Classes that use Blended Online Learning (BOL) and only Asynchronous Online Learning (AOL). A combination of asynchronous di LMS and synchronous di Microsoft Teams carries out BOL. The research design is in Figure 1.

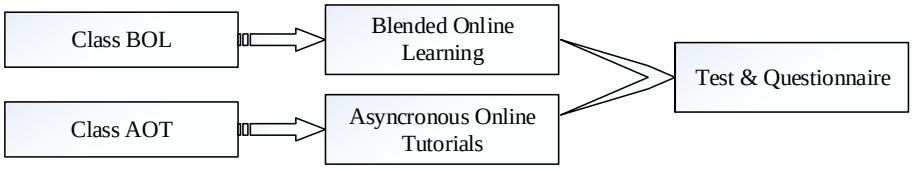

Figure 1. Research design

2.2. Participants

The sample was selected based on research interests. At the time this research was conducted, the number of students who chose the abstract algebra course was limited, so the research was carried out as a quasi-experiment involving all students without random selection. It consists of all 27 students who took the Abstract Algebra course online. Students were given the freedom to choose between blended and asynchronous online learning. It was found that 12 students consisting of 4 male and 12 female learned using blended online learning, while the remaining 15 students consisting of 8 male and 7 female took asynchronous online learning.

2.3. Research Instruments

The instruments used in the research were a questionnaire and learning outcomes test of the abstract algebra course. Test trial score data were analyzed using the Pearson Correlation with SPSS v22. The test validity criteria are in Table 1.

Table 1. Test validity criteria

Sig.	Pearson Correlation Value	Criteria
Sig. (2-tailed) < 0,05	Positive	Valid
Sig. (2-tailed) < 0,05	Negative	Invalid
Sig. (2-tailed) < 0,05	Positive/ Negative	Invalid

Table 1 shows that the test is valid if the Sig. (2-tailed) value is small from 0.05 dan potitive. Other than that, the test is invalid. The test consists of an 8-item essay. It was tested on 48 students who had previously obtained abstract algebra to obtain validity. The test validity results are in Table 2.

Table 2. Test validity results

		Correlations								
		Item1	Item2	Item3	Item4	Item5	Item6	Item7	Item8	Item_Total
Total_ Score	Pearson Correlation	0.670**	0.680**	0.715**	0.344*	0.438**	0.588**	0.569**	0.647**	1
	Sig. (2-tailed)	0.000	0.000	0.000	0.017	0.002	0.000	0.000	0.000	
	N	8	8	8	8	8	8	8	8	48

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 2 shows that the Sig. (2-tailed) The value of the 8-item test is below 0.05. This indicates that the test has valid criteria. Tests can be used to measure students' abstract algebra learning outcomes. The researcher created a test according to the indicators of abstract algebra material. Examples of abstract algebra questions are in Table 3.

Table 3. Example of item test

Indicator	Item Test	Answer	Score
Understand mathematical proofs	Prove: G is a group and applies $(a.b)^2 = a^2.b^2$ for each a, b ∈ G if and only	(⇒) Take any a, b ∈ G $(a.b)^2 = a^2.b^2$ (a.b)(a.b) = a.a.b.b	 0.5 0.5

Indicator	Item Test	Answer	Score
	if G is an abelian or commutative group!	$a.b.a.b.b^{-1} = a.a.b.b.b^{-1}$	1
		$a.b.a = a.a.b$	1
		$a^{-1}.a.b.a = a^{-1}.a.a.b$	1
		$b.a = a.b$	1
			1
		(⇐)	
		$(a.b)^2 = (a.b)(a.b)$	1
		Because G abelian then	0.5
		$(a.b)^2 = (a.a)(b.b) = a^2.b^2$	1
		So G is abelian or commutative.	1.5
			10

Questionnaires were issued to get an overview of student perception about implementing asynchronous and blended online learning. The questionnaire consisted of 33 items with 27 closed and six open questions. The indicators included in the questionnaire are given in Table 4.

Table 4. Indicator of questionnaire

Indicators	Questions	
	Closed	Opened
Abstract Algebra Course	3	6
Course Preparation	6	
Course Implementation	15	
Facilities	3	
Total	27	6

In the questionnaire with closed questions, students give a check mark (√) in one of the selected columns, namely Yes or No. Examples of questionnaires with closed questions are in Table 5.

Table 5. Example of closed question

Questions	Yes	No
Did you read the abstract algebra module thoroughly?		
Did you follow the webinar tutorial on the abstract algebra course?		

In the open-ended questionnaire, students write their opinion in the answer column. Examples of questionnaires with open questions in Table 6.

Table 6. Example of open question

Questions	Answer
Why did you follow or not the webinar tutorial on this Algebraic Structures course?	...
What are some of your obstacles with participating in webinar tutorials?	...

2.4. Data Collection Technique

This research sought to collect data on student perceptions of a combination of asynchronous and synchronous online learning implemented through the LMS Moodle. A questionnaire was used to gauge student perceptions, while tests measured learning

outcomes. Questionnaires were distributed to all students through Google Forms at the end of the tutorial meeting. The test instrument was in the form of essay questions, as many as 8. The test is given at the last meeting as a posttest. The posttest results of both classes were analyzed using SPSS v22 to determine the significant difference in learning outcomes between BOL and AOL classes.

2.5. Settings and Procedure

The online learning at Open University is conducted asynchronously and presented in LMS using MOODLE software to create online (web-based) lecture materials, manage learning activities and the results, and facilitate interaction, communication, and collaboration between lecturers and students. Figure 2 shows the LMS of asynchronous learning activities on the website https://elearning.ut.ac.id.

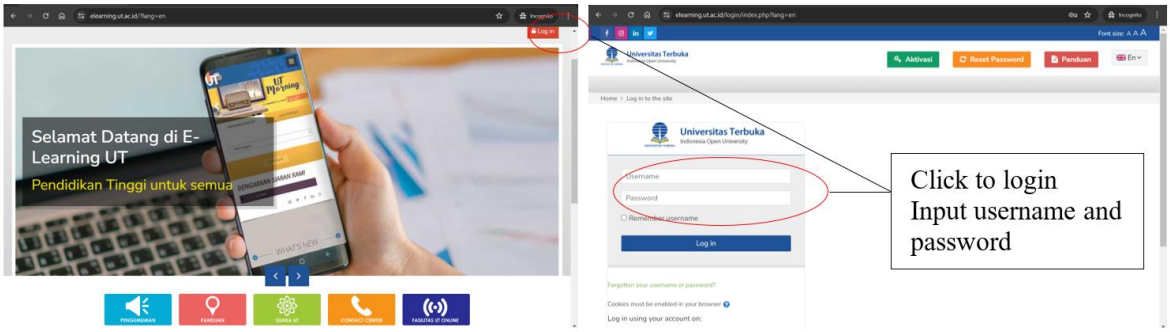

Figure 2. Display of the online learning in LMS

The online learning comprises eight sessions, each lasting for a week. This implies that the effective student-learning process lasts two months in one tutorial period. Each session consists of material presentations, discussions, and additional assignments, especially in the 3rd, 5th, and 7th sessions. Figure 3 shows 8 sessions in the LMS.

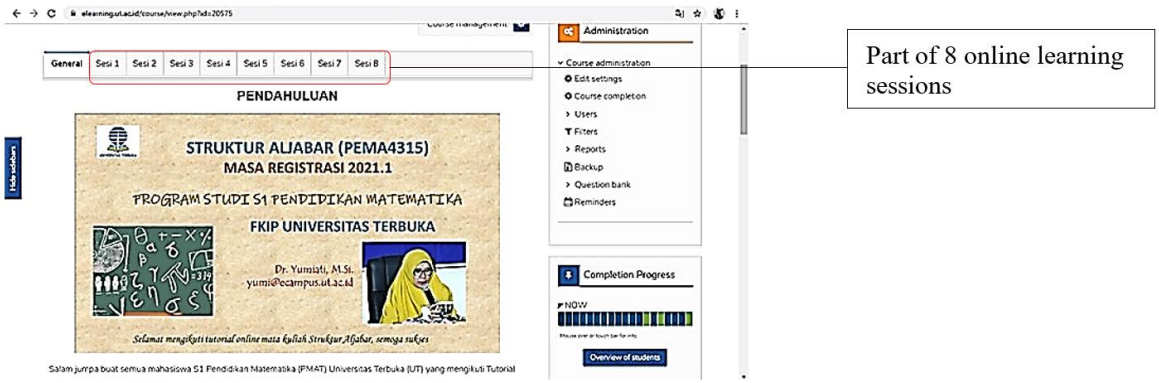

Figure 3. Display of 8 sessions in LMS

The material is displayed in the form of Microsoft PowerPoint. Subsequently, the discussion contains questions about each session's material or material considered problematic. The blended online learning gets an additional synchronous run live, while the implementation of synchronous online learning uses Microsoft Teams, as shown in Figure

4. The implementation was conducted for six sessions, including the end of the 3rd session to the end of the 8th session of online learning via LMS Moodle. The material discussed using synchronous tutorials was considered challenging during LMS Moodle or asynchronous tutorials.

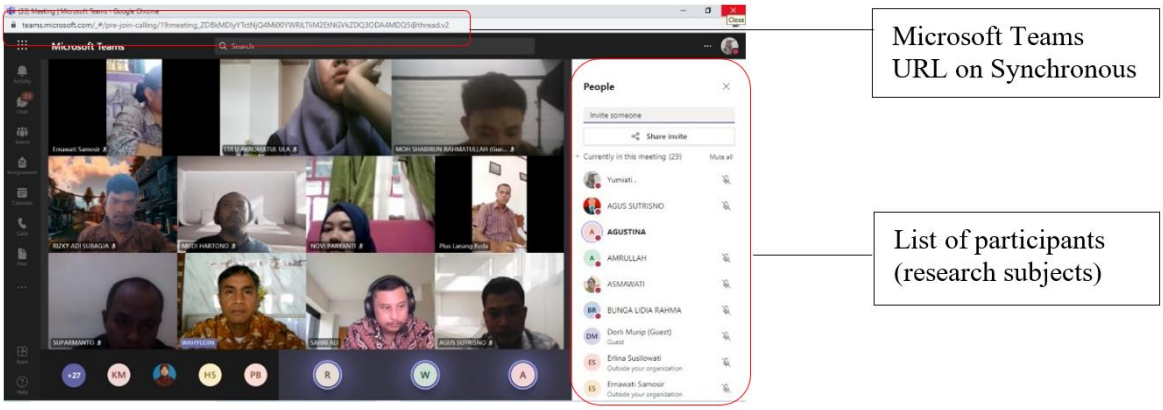

Figure 4. Display of synchronous in microsoft teams

The synchronous online learning model contains the material that students consider difficult to present. The material is presented in Microsoft Word, which functions as a whiteboard using a direct learning model. The tutor presents the material, gives examples, and then continues with questions and answers. At the end of the 8th online learning session, the tutor gave a questionnaire to the students.

2.6. Data Analysis

Data on student learning outcomes on abstract algebra material are obtained through tests given at the last meeting as posttests. Posttest results were analyzed to determine the significant differences between the two classes: Blended Online Learning (BOL) and Asynchronous Online Learning (AOL). The posttest of both classes is independent. Analysis of posttest results using the Independent Sample T-Test through SPSS v.22. The first testing stage is to check the distribution of normally distributed data. Then, the homogeneity will be checked to determine if the data distribution is of the same diversity. The last stage is to conduct an Independent Sample T-Test to determine the significant difference in learning outcomes of the BOL and AOL classes. If the post-test is not normally distributed using the Mann-Whitney Test.

The analysis of student perceptions involving blended online learning was taken from questionnaire data, which was analyzed qualitatively. Data obtained through the questionnaires were classified into the perception of Abstract Algebra course difficulty level, learning preparation, implementation of learning, and facilities. The perception of the Abstract Algebra course difficulty level was described using student opinions and the frequency of repeating the course. In assessing learning preparedness, the research sought to understand how well the students were prepared to comprehend the module's learning resources and establish the challenges faced when accomplishing the tasks.

Furthermore, perceptions regarding learning implementation were aimed at determining how blended asynchronous and synchronous online learning was conducted,

inquiring about synchronous learning only, analyzing the weaknesses of each learning model, and analyzing the students' input in improving the materials. Finally, perceptions related to facilities aimed at assessing the facilities' condition for each student, particularly looking at the internet connectivity network and signal strength.

3. RESULTS AND DISCUSSION

3.1. Results

The research obtained results in the form of student perception data collected through questionnaires and the students' learning outcomes in abstract algebra through tests, comparing students who received blended learning with those who experienced asynchronous online learning. The results of the questionnaire and tests are described as follows.

Perception of abstract algebra course difficulty level

The research found out that Abstract Algebra was one of the most difficult courses for students. Out of the 27 students who filled out the questionnaire, seven of them (26%) were examined more than once whereas one (1) student was examined more than three times as illustrated in Table 7.

Table 7. The number of students and the frequency of taking abstract algebra courses

Frequency	Number of Students
1 time	20
2 time	5
3 time	1
> 3 time	1
Total	27

Out of seven students who were examined more than once, one student scored C as the highest, two scored D, and four scored E. In establishing the challenges encountered while undertaking the course, 78% (n=21) of students reported having had difficulties understanding the content.

Learning Preparation

In establishing the student's readiness for learning, 85% (n=23) of the students read learning resources other than modules and other sources obtained from the internet. Open University provided teaching materials in printed form that students were required to have as the primary learning resource. Open University, which is an open and distant university, requires students to study independently through these printed teaching materials. However, based on the results from the questionnaires, only 52% (n=14) of the students thoroughly read the module. The reason claimed by the students for incomplete reading was that Abstract Algebra material was too difficult to analyze and comprehend. Others experienced time constraints since they were learning and working as a teacher at the same time.

Learning Implementation

The presentation of online learning materials was displayed in various forms such as Word, PowerPoint, and video. From the results, 81% (n=22) confirmed that video-aided materials or PowerPoint with voices made it easier to understand asynchronous online learning in addition to the available forms. In each asynchronous online learning meeting, the tutor provided a discussion and an assignment for the 3rd, 5th, and 7th meetings. The results showed that students answered discussions and tutorial assignments in the form of Word, PDF, or handwritten files with percentages presented in Table 8.

Table 8. Percentage of student file forms

File Form	Number of Students (%)
Handwriting	24
PDF	13
Microsoft Word	63

The research established that Microsoft Word usage was dominating the discussion answers and the assignments done by the students. In determining the implementation of online learning, 67% (n=18) of the students said that asynchronous online were less effective. Some of the challenges identified in implementing asynchronous tutorials included everything must be learned alone, the course was difficult, hence the need for a tutor to explain the concepts directly, and the material content was too much. The PowerPoint materials were difficult to understand, and it was hard to ask questions directly to the tutor. Some tutors were less active either in responding or assessing the discussion. Furthermore, other tutors did not provide discussion materials, making students deviate from the material. An example of a student file form is in Figure 5.

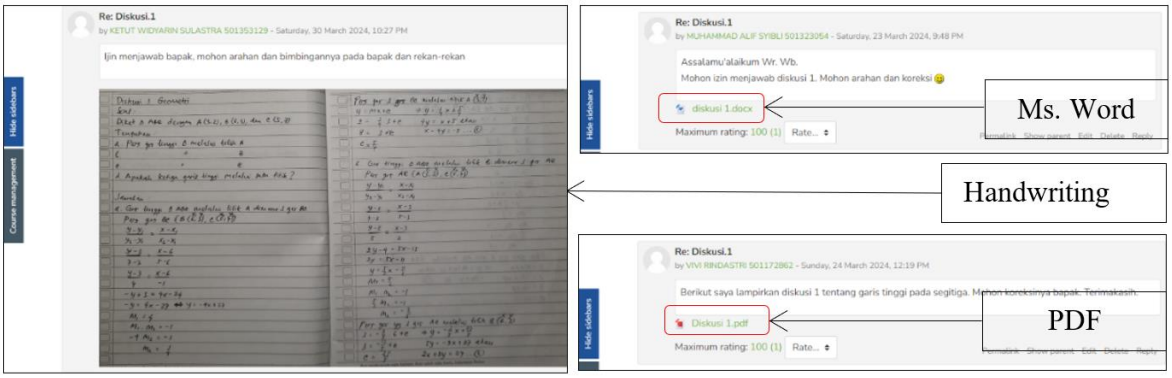

Figure 5. Example of student file form

However, according to students, the advantages of asynchronous tutorials compared to synchronous tutorials include being more flexible in time and can be done anywhere, practicing self-study, and cost-effective. For this asynchronous tutoring to be understood well, inputs from students were considered, such as more examples of questions and discussions, additional video explanations for the material, feedback from tutors in discussions and assignments, and combined with the synchronous tutorial.

Based on the analyzed data, there were 12 out of 27 students followed the synchronous tutorial. From those 12 students, it turned out that only one (8%) was familiar

with Microsoft Teams. At the same time, Open University provided accessible facilities in using Microsoft Teams email with a One Drive capacity of 1000 gigabytes. This needed more research in terms of the usability and usefulness of Microsoft Teams for students.

In the implementation of the synchronous tutorial, the tutor gave directions to read the module first so that during the tutorial, students could ask questions that were considered difficult. Every week, students asked what material would be discussed in the next tutorial. It was established that 100% of students read the module material before the implementation of the synchronous tutorial which was held six times. It turned out that not all the 12 students wholly followed the tutorial as shown in Table 9.

Table 9. Students following synchronous

Frequency	Number of Students
2 time	3
3 time	1
4 time	1
5 time	3
6 time	4
Total	12

Most students 33.3% (n=4) followed synchronous online learning 6 times, some factors that contributed to incomplete following included, limited internet network (39%), and (44%) reported having challenges in time due to other activities. The research established that the best presentation of material in the synchronous tutorial was video, followed by Word, and then PowerPoint. Other media to facilitate understanding of the material in the synchronous tutorial was video or PowerPoint with voices 89% (n=24). There are 92% (n=25) of students stated that it was easier to understand the material through synchronous than the asynchronous tutorial. Further, the synchronous tutorial was similar to direct face-to-face lectures where tutors explained and provided opportunities for students to ask for elaboration where the content was not well understood.

The challenges involved in implementing the asynchronous tutorial were difficulty in asking more profound questions about materials that were difficult to understand. This challenge can be overcome through synchronous online learning. Therefore, all students enjoyed the synchronous implementation of tutorials. The existence of discussions, questions, and answers between students and tutors provided a new nuance for Open University students in the mathematics study program. So far, students and tutors and between students discuss indirectly without meeting face to face. Furthermore, students confirmed that synchronous was advantageous compared to asynchronous tutorials because they could communicate directly with their tutor 75% (n=20), and the rest said it was easier to understand the material 17% (n=5), while 8% (n=2) said it was more effective.

Internet connectivity was also a challenge as reported by 67% (n=18) of the students. There are even students who have to look for signals outside their homes to get a good network. And the rest are constrained by busyness. However, with the identified challenges, the students provided the following solutions, increasing the duration and media sessions, for materials that are difficult to comprehend, and elaborating on discussion questions. Even though all students who participated in the synchronous tutorial enjoyed the synchronous

tutorial process, 44% (n=12) stated that they disagreed that the asynchronous could be replaced with the synchronous tutorial. Instead, they preferred combining the asynchronous with the synchronous tutorial. This combination tutorial is approved by 100% of students for the implementation of the next Open University tutorial. They also suggested that learning time should be increased concerning the number of modules or the number of credits. This is new information regarding students' perceptions of blended online lectures on abstract algebra using a combination of synchronous and asynchronous.

Facilities

The implementation of blended online learning was dependent on the internet network. According to 59% (n=16) of students, the internet network in their area was unstable, while 11% (n=3) said the connectivity was poor, it was concluded that 70% (n=19) of the network in the regions was poor. Regarding the blended online learning implementation location, 86% (n=23) of students stated that they were at home and the rest at work. Meanwhile, most of the students (74%; n=20) used cell phones in participating, and 25% (n=7) used laptops.

Learning Outcomes

The tutorial value was calculated based on the value of participation or attendance (20%), activeness in discussion (30%), and average assignment (50%). The result is shown in Table 10.

Table 10. Student learning outcomes

Groups Online	Score
Blended Online Learning (BOA)	74.3
Asynchronous Online Learning (LOA)	52.2

Table 10 shows that students who took the blended online learning had higher learning outcomes than students who enrolled asynchronously only. Learning outcomes data is carried out by the Normality Test as in Table 11.

Table 11. Test of normality learning outcomes

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	class	Statistic	df	Sig.	Statistic	df	Sig.
learning_outcomes	BOL	0.000	2	0.000*	0.000	2	0.000
	AOL	0.000	5	0.000	0.000	5	0.000

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

In Table 11, we can see that the significance value (Sig.=0.000) is less than 0.05, which indicates that the posttest data of the two classes are not normally distributed. Furthermore, posttest data was carried out by the Mann-Whitney Test to see the significance of differences in learning outcomes of the two classes. The T Independent Sample T-Test is shown in Table 12.

Table 12. Mann-Whitney Test of learning outcomes

Test Statistics[a]	
	learning_outcomes
Mann-Whitney U	43,000
Wilcoxon W	163,000
Z	-2,000
Asymp. Sig. (2-tailed)	0,023
Exact Sig. [2*(1-tailed Sig.)]	0,021[b]

a. Grouping Variable: class
b. Not corrected for ties.

In Table 12, the value of Asymp. Sig. (2-tailed) is 0.023 which indicates that there is a significant difference in student learning outcomes data using BOL and AOL. Students who use BOL obtain significantly higher learning outcomes compared to AOL students. This result becomes new information obtained in this research. Blended learning has been shown to have a good impact in helping students understand Abstract Algebra subjects.

3.2. Discussion

Many students were assessed more than three times for the Abstract Algebra course indicating the difficulty encountered in comprehending the content (see Table 7). This finding was similar to previous research conducted by Yuniati (2014), Arikan et al. (2015), and Agustyaningrum et al. (2020) stating that students encountered difficulties in learning Abstract Algebra. The students further discovered that they could not think abstractly and interpret verbal expressions or formulate mathematical expressions (Arikan et al., 2015). The most crucial concept that needed to be mastered by students in abstract algebra courses was the ability of mathematical proofs. This was inhibited by the student's deficiency at the readiness level, commencing in proof (perception ways of math and proof), students' ways which they used in the proof, being in the form of sampling rather than being conception, and students' awareness of knowledge essential for proofing and still having difficulty in the proof.

Furthermore, one of the problems at Open University and in all distance universities in the world was the heterogeneous background of students. This negatively impacted the students in the Mathematics Education study program studying subjects, especially abstract algebra, due to a lack of initial knowledge. The characteristic of mathematical material is a hierarchy where students must have mastered the previous material. This heterogeneity of student abilities resulted from the Open University registration procedure that didn't go through the academic selection mechanism (Hadjinicolaou, 2014). For Open University students, the challenges encountered in comprehending the Abstract Algebra course content made them unable to finish reading the module to prepare for the synchronous tutorial. Learning preparation was very important for students because it affected the learning outcomes (Dangol & Shrestha, 2019). Moreover, the learning duration was critical in preparing the content, as highlighted by Rigo and Mikuš (2021), who examined online learning preparation about time. For synchronous, most students required 30-60 minutes for lesson preparation, while for asynchronous, it took between 60-90 minutes. This cannot be

concluded if it is converted to the length of reading the Open University module, and how many modules have been read by students.

The research summarized the students' perceptions of the strengths and weaknesses of the three online learning models as discussed. Asynchronous tutorials were singly handled by students indicating the difficulties faced, and this is the opinion of Pakhomova et al. (2016), who said that the challenge of online learning (asynchronous) was due to the failure of students to regulate their learning process. The difficulty of the Abstract Algebra course required a direct explanation from the tutor, but students lacked the interaction asynchronously. Students could not get help when they needed it, according to Hung et al. (2020). The tutor could answer a few days later, even in a matter of weeks (Rigo & Mikuš, 2021).

Students complained about too much Abstract Algebra material, while the explanation in the asynchronous online learning was only in PowerPoint. This is also found in the research of Batmang et al. (2021), in which online asynchronous material and discussions were only provided in PDF or slide form. Furthermore, tutors do not provide feedback in discussions and assignments (Ebner & Gegenfurtner, 2019), which brings confusion to the students. Generally, it is crucial to provide feedback to the students since students can use it to improve performance, self-regulation skills, and motivate them to work hard (Cavalcanti et al., 2021; Martínez-Argüelles et al., 2013). These problems are likely to cause low levels of student participation in online learning (Kear et al., 2012). However, online learning in algebra courses can be successful, as stated by Lin et al. (2017), with the following conditions. First, tutors must prepare learning materials well, and adjust to the student's initial abilities. Second, asynchronous discussion can be improved by providing interaction opportunities among all the students, or students and tutors. Third, student performance should be assessed during and after discussions, provide regular feedback, and obtain student feedback on the accessibility of online classes.

Additionally, asynchronous online learning will be effective when using audio or video (Ene & Upton, 2018). Students can play the audio or video repeatedly in a bid to understand the problematic material. This is interesting because the suggestion from students based on open questions in the questionnaire is that asynchronously online learning be equipped with a video explanation of the material. Indrawati (2021) said that the use of archiving video media and online learning was proven to be able to affect students' learning and innovation skills so that they can become a reference for further research. It needs further research, on how effective is asynchronous online learning equipped with video. The asynchronous tutorials also have advantages, as expressed by students in the questionnaire. Buxton (2014), Ebner and Gegenfurtner (2019), and Hung et al. (2020) said that asynchronous online learning is more flexible over time. Therefore, students can learn the material anywhere and anytime (Sumarmi et al., 2021). Access to materials can be done freely, as well as completing discussions and assignments at their convenience (Rigo & Mikuš, 2021). Asynchronous tutorials can also train students to learn independently since students are expected to take the initiative and manage learning on their own (Darma et al., 2019).

Students suggest asynchronous online learning is complemented by synchronous online learning. This is to say, that learning problems in asynchronous can be overcome through synchronous online learning. For example, when students have difficulty understanding the material in asynchronous learning, they can ask for clarification during online synchronous meetings. The much-needed feedback from the tutors can be given easily and quickly in synchronous learning. Furthermore, the understanding of material obtained in online asynchronous can be strengthened in online synchronous through discussions and questions and answers with tutors. Students enjoy interactivity and various ways of communicating synchronously online, which they say is effective compared to face-to-face tutorials (Kear et al., 2012). Synchronous online learning allows participants to communicate directly with lecturers and can provide immediate feedback. In addition, any comments or questions that arise from students immediately attract the attention of tutors (Ebner & Gegenfurtner, 2019). Therefore, the integration of the two methods of learning is favored by Open University students, as shown in the research results. The power of blended online learning provides a safe, comfortable virtual space and real-time communication through synchronous learning, assisted with the ease of material use and evaluation through asynchronous online (Rigo & Mikuš, 2021).

The following suggestions are expected to make blended tutorials enjoyable, according to the research. Firstly, additional presentation of material in the form of videos in asynchronous tutorials. Secondly, synchronous duration is added, and finally, discussion of material at synchronous meetings is challenging because of material complexity. Therefore, various responses regarding the number of times synchronous tutorials in online combined tutorials can be carried out need in-depth research by Open University. The results of Choi and Walters (2018) concluded that students who had more synchronous sessions scored better than those who attended fewer synchronous sessions. This should be a consideration for Open University to determine how much synchronous online will be applied to blended online learning. The implementation of blended online learning has various problems. The obstacles given included busyness and the internet network. Most Open University mathematics education study program students are already working as teachers, which makes their schedules tight, and sometimes, work schedules coincide with synchronous online (Rigo & Mikuš, 2021). The obstacles related to the poor or no internet network in online learning have also been raised by Lemay et al. (2021) and Rigo and Mikuš (2021).

Innovation in technology in education in Indonesia is not an easy matter because most students do not have internet access. Even though Internet cafe networks have been developed in various cities in the region, access to the Internet is still considered quite expensive and not easy for most Open University students who live in remote or rural areas. On average, students travel for approximately 2 hours to find a place with good internet connectivity (Yumiati & Wahyuningrum, 2017). Most students conducted online learning at home. This aligns with the finding of Rigo and Mikuš (2021), which found that learning from home was the most preferred thing for students in online learning. Students can view or replay videos and audio in areas they do not understand (Darma et al., 2019; Smith & Suzuki, 2015). The results also show that the majority of students use cell phones in online

learning. The students prefer to use smartphones compared to other devices in carrying out online learning (Darma et al., 2019; Lemay et al., 2021). This is due to the ease of obtaining a smartphone compared to a laptop; smartphones are cheaper and lighter than laptops (Rusli et al., 2020). Currently, smartphones are necessary to all people, and for many, mobile phones are the only gadgets that connect them to the outside world (Lemay et al., 2021).

The results shown the differences in learning outcomes between the two groups of classes. These differences are significant because blended online learning makes students active and increases participation (Yamagata-lynch, 2014). Through synchronous communication, students discuss directly with tutors and other students, while in asynchronous communication, students can take time to reflect and prepare responses to discussion topics carried out synchronously. Students using blended online learning provide a strong sense of connection compared to those relying only upon asynchronous learning. This strengthens Moorhouse and Wong (2022), who said that synchronous and asynchronous learning alone is not enough to support student learning. Students getting treatment attained a better level than students taught by conventional teaching (Putra et al., 2020). The dominant and significant factor in influencing the students' mathematics performance was learning motivation and self-regulation (Doño & Mangila, 2021; Nofriyandi & Andrian, 2022). Students needed better problem-solving skills in algebraic word problems (Iilonga & Ogbonnaya, 2023).

4. CONCLUSION

This research examined student perceptions of blended online learning and its effect on learning outcomes in abstract algebra courses. From the results, the perception of the difficulty level of abstract algebra courses strengthened the results of previous research, which concluded that abstract algebra material was complex. Students have challenges when learning is conducted asynchronously using the LMS Moodle, as Open University does in online learning. Students complain about tutors' boring PowerPoint presentations of material, making communication between tutors and students less effective. The students suggested that asynchronous online learning should be equipped with a video explanation of the material. Its effectiveness may be investigated further to find how effective asynchronous online learning is equipped with video. Additionally, the results show that blended online learning is attractive to all students. Therefore, students expect Open University to implement a blended online learning model to provide study assistance to students.

This model will help students learn the material in advance asynchronously, besides being flexible enough to be learned anywhere. Furthermore, during the synchronous time, students will receive a detailed explanation regarding material from the tutor and maintain close contact between the students themselves and the teachers, which will necessitate dialogue. This will undoubtedly increase the learning outcomes, as evidenced by blended e online learning. Student learning outcomes using blended online learning are significantly higher than asynchronous online learning. However, this research had limitations, particularly regarding the number of students who chose the abstract algebra course. The internet connection was sometimes unstable for students during synchronous online learning. This research contributes to the growing body of evidence supporting the

effectiveness of blended learning in complex subject areas and offers insights for improving online education strategis. Further research is necessary to investigate the effectiveness of blended online learning for abstract algebra courses on mathematical proof abilities.

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