A COMPARISON OF STUDENTS' LEARNING OUTCOMES IN ADVANCED MATHEMATICS COURSES THROUGH HYBRID LEARNING

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ABSTRACT

After the COVID-19 pandemic was over, the teaching and learning process in the world of education underwent several changes. The COVID-19 pandemic forced the global learning community to transition within a very short period of time from the traditional in-class method of learning to a mode of online learning. After the pandemic started to subside, even though it had not wholly disappeared, learning was carried out using hybrid learning. Hybrid learning was continued to prevent the re-emergence of the Covid virus by reducing the number of students in each face-to-face class. The purpose of this study is to determine whether there are differences in learning outcomes between online learning and offline (face-to-face) learning. Based on normality and homogeneity tests as well as different tests on pretest and posttest scores, the results show that there are differences in posttest learning outcomes for the Online and Offline Groups, which can be seen from the P Value (Sig.) (0.005) < 0.05. Differences also occur in the results of the work; students in the Online Group were more courageous in trying to solve things in a different way from what the educator teaches compared to students from the Offline Group. With an awareness of these differences, future research can create a learning model that combines online and offline learning to improve student learning outcomes.

Keywords: *online, hybrid learning, integral, offline, comparison of learning outcomes*

INTRODUCTION

The COVID-19 pandemic left an indelible mark on individuals, both positively and negatively. In the world of education, the negative impacts include worsening interactions between educators and students such as communication breakdowns, a lack of personal touch, and especially poor concentration experienced by students (Sahoo et al., 2021). In addition to the negative impacts that may occur, there are also some positive impacts that can be used as a tool to develop new learning models that are more relevant to today's digital era. During the pandemic, due to the fast access to direct communication, the world of education is trying to find a substitute for direct, face-to-face contact, starting with Whatsapp and leading to more sophisticated methods, such as video conferencing and making teaching materials such as videos and other media. Since education is trying to solve problems due to the absence of direct interaction, various models, methods, and learning tools have been created (Abutayeh et al., 2022; Nguyen & Tran, 2022; Pebriantika et al., 2021; Renaldi et al., 2022). Attempts to replace this direct communication are ongoing according to the capabilities of the educational institutions and

educators themselves, so the process still needs to be investigated and improved.

Except for the hardware, the current learning model must be left behind to be enhanced because the learning model for direct, face-to-face communication is different than the learning model using technology. Research conducted by Anjani & Ulfah (2022) suggests that during online learning there is a significant relationship between mathematical reasoning abilities and student learning styles. Murniasih et al. (2022) found a conflicting perception between teachers and prospective teachers in online learning. The teachers felt they had to give many tasks to students in online learning, while prospective teachers felt the opposite. The findings of Wulandari & Alyani (2022) stated that in online learning, self-regulated learning was important, especially when elementary school students learned about fractions. The world of education is still looking for the most appropriate model for learning models where direct communication still needs to be obtained.

The various findings of studies of online learning agree that online learning is an advancement in the world of education, since the new methods, models, and learning tools developed after the pandemic involve technological advances. Research from Harti et al. (2021), Sefriani et al. (2021), Sunarto (2021), and Thamrin et al. (2022) states that the role of technology in education is increasingly needed when direct encounters are not possible. Technology is preferred by the current generation of learners (Hariadi et al., 2019; Sunarto, 2021). Thus, a learning model that uses current technology can make students more interested in carrying out the learning process. This is consistent with the findings of Panyajamorn et al. (2022) that the elearning model was able to increase student retention. Hadiyanto et al. (2022) stated that learning through blended learning improved students' performance in Research Methodology courses. This pandemic showed that the role of technology in the world of education, which was designed before the pandemic, is something new and brings more benefits to the world of education.

In fact, however, learning with technology is something new in the world of education. The findings from Pozo et al. (2021) on 1,403 elementary and secondary school teachers in Spain stated that the use of technology was more reproductive than constructive, considering the inadequate ability of educators in their use of information technology. Another difficulty experienced by educators regarding technology was having an unstable internet connection, which often caused them to be disconnected when teaching (Rahayu et al., 2022). Considering the educators' lack of skills in technology and the difficulty of internet access, Burrows et al. (2021) organized courses for educators through a program called Teachers' Educational Technology Competency. However, the role of technology in education cannot be underestimated. In fact, in some developed countries such as the United Kingdom, Mayhew et al. (2022) found that the use of technology among academic staff was considered more enjoyable and useful, which was an interesting finding because it contradicted some of the references they read. Meanwhile, according to Manyeredzi & Mpofu (2022) Zimbabwe had experienced rapid progress in the use of technology since the pandemic, especially the use of smartphones, with a penetration rate of 87% for them, as well as statements of willingness from teachers to use smartphones as digital instructional interface devices. Technology's role is to aid good educational practice, although preparing infrastructure and especially human resources requires a lot of effort.

Integral material is part of the Advanced Mathematics course in the Information Systems study program at an Information Technology-based university in Indonesia. Prior to the COVID-19 pandemic, the teaching and learning processes were delivered with conventional methods. The lecturers gave lectures, accompanied by question sessions, which resulted in poor learning outcomes. Only 38.23% of students managed to get a score above 56, which is the lower limit for graduation. During the pandemic, without proper preparation from both lecturers and students, the learning and teaching of the material were done fully online through web conference facilities such as Google Meet assisted by Moodle-based learning applications. As a result, the learning outcomes were not too different from conventional models.

The Advanced Mathematics course in Information Systems Study Program at the university is a compulsory subject for students in the second semester, with the general goal of getting students used to using correct mathematical calculation techniques in order to solve problems,

both in everyday life and in business. This course is intended for second-semester students meeting 16 times for one semester, with each session being 150 minutes, and the prerequisite for Advanced Mathematics is the Basic Mathematics course. Advanced Mathematics is compulsory because it is foundational for the Information Systems major. The material taught is Differential, Integral, Boolean Algebra, Graph, and Tree. This course has three program learning outcomes (PLOs) that are then translated into four course learning outcomes (CLOs). Integral material is included in the first PLO, in which students identify, formulate, and solve problems of the information needs of an organization. The first CLO is that students solve problems in everyday life or in the business world by using differential and integral techniques. From the CLO description, integral material is studied so that students are not only skilled at solving pure integral problems but also integral problems that are applied in the business world. In the Advanced Mathematics course, Integral will be applied to the problem of determining Surplus Consumers and Surplus Producers. Three meetings are needed for Integral material, in which each meeting is divided into 150 minutes of face-to-face time, 180 minutes of self-study, and 180 minutes for responding. Before the pandemic, learning was carried out conventionally in that teachers and students were in the same place using Moodle-based applications. Integral material is part of Calculus material, essential material in the development of technology and science (Yerizon et al., 2022), and is the field of study of the students in this study. Even though integral material is considered necessary, many students find it difficult and many teachers try to overcome this by using media such as ebooks or other applications. Research from Awaludin et al. (2020) and Machromah et al. (2019) state that the addition of media can improve students' understanding because, apart from being able to repeat it, it is also more explicit in visualization.

Students who take Advanced Mathematics courses are in the millennial generation with ages range from 19 to 21 years, and they are students who are familiar with advances in information technology (Roehling et al., 2010) that are appropriate to their field, i.e., information systems.

The level of class interaction between teachers and students or among students has been conditioned in ideal conditions because both online and face-to-face classes know each other, and their relationship with the teacher occurs not only in this class but also in other classes. In the Advanced Mathematics class, hybrid discussions often occur between the teacher and the students and group discussions among students to minimize any awkwardness in communicating. In addition, the teacher also provides material in a style that is acceptable to the students based on their age, such as using the latest communication tools and media.

Teachers already have a comfort level with media because tertiary institutions are information technology based, so all the educators have used information system media or applications supported by stable internet access and have been trained in the use of media beforehand. Technological support at this research location is very feasible for education and has Wi-Fi access throughout the campus and classrooms with supporting learning equipment. Meanwhile, the school provided support through Wi-Fi access at home for students to take part online during the Covid-19 pandemic.

After the pandemic subsided, according to the recommendations of the Indonesian government, learning was held in a hybrid learning manner to reduce the number of participants in face-to-face classes. Classes are composed of half the students offline while the other half of students participate online. Likewise, for offline classes, tests are given to students in a particular room and the students write their answers on paper answer sheets. In contrast, tests for online courses are given online through an application on campus called Brilliant.

Hybrid learning here refers to the definition of Putri Uleng et al. (2022), which stated that hybrid learning is learning in which some participants attend online and some participants attend offline, or face-to-face, with the teacher. In offline learning, the teachers and the students meet face-to-face in the same place, while in online learning, the teachers and the students are not in the same place but use web conferencing or other online technologies as a communication tool.

With the pandemic subsiding, preparations for conducting learning both online and offline are better because both educators and students have been trained to improve the learning process by capitalizing on their experience during the

pandemic. Educators are equipped to present material more interestingly, even though it is online, and students are better prepared to study independently. Recommendations for the ten preparations from Bringula et al. (2021) for online classes have been tried, especially their suggestions for providing time for consultations, creating collaborative types, and being alert in understanding students' difficulties. Evaluations are held by the learning model, meaning that assessments and evaluations are stored online for students who take part offline. The review is open book because the students are expected to analyze the questions given. In addition, because there are students who take the exam online from a place separate from their educators, if the exam is a closed book test, educators also need to be sure students are not cheating (Liu, 2020).

Integral learning in Advanced Mathematics courses is carried out online and offline simultaneously. The teacher provides material to students who are off campus through Google Meet (online) and to students who are on campus face-to-face (offline). Communication with students who take part in the class online is supported by a camera so the teachers can freely move while teaching the students who take part offline. Before the teaching and learning process begins, both classes are given Semester Learning Plans (SLPs), lecture materials in the form of Student Teaching Materials (STM), and Student Worksheets to be studied first through the Moodle-based Brillian application, so that the students are prepared to attend the classes. This is in line with Howard and Major (2004) and Turan and Ulutas (2016), who stated that teaching tools should be given first to students so that students are more prepared to participate in the teaching and learning process. The SLP is a course lesson plan containing material, teaching and learning activities, time, and evaluation. The STM is made by the teacher so it can be studied both before and after the teaching and learning process.

Since the teacher uses two different ways of teaching at the same time, a research question arose for us: Are there any differences in students' learning outcomes for Integral material in Advanced Mathematics courses taught online and offline? To answer this, we quantitatively reviewed the students' learning outcomes and analyzed the students' work.

This question arose because each method has its own advantages and disadvantages. According to Najib and Mursidi (2021) and Valentino et al. (2021), online learning has the advantage of being a learning tool that is highly favored by Millennials, and it also has a more flexible study schedule and is preferred by students. In addition, online learning should have a lower cost because it eliminates physical learning places. The weakness of online learning is the lack of human contact. Teachers often feel they have no control over the learning activities, whereas students often find it difficult to concentrate and engage in learning. On the other hand, offline learning has the advantage of a definite schedule, so that students can automatically learn in a structured manner. Also, direct monitoring from educators often raises students' motivation. In general, online and offline learning have their respective advantages, but online learning has the advantage of forming quantitative thinking, thinking at a higher level, and self-regulating learning (Dumford & Miller, 2018; Pei & Wu, 2019), while offline learning has the advantage of interacting socially and being easier to understand because students can directly ask the teacher questions (Wiebe et al., 2022).

METHOD

This is an experimental study consisting of two classes, namely classes with online learning and classes with offline learning. This study involves 65 students participating in the Advanced Mathematics course and consists of 31 students who took part online and 34 students who took part offline. Each class was given a pretest and posttest.

The learning process began with making learning tools for Advanced Mathematics courses, which consisted of Semester Learning Plans, learning materials, and test tools. The validity and reliability of each were measured, with results shown in Table 1.

Furthermore, this learning device was validated by experts and the results were analyzed using descriptive statistics with the average score of the completed questionnaire. The single measures of Interrater Coefficient Correlation (ICC) and Cronbach's coefficient alpha were used as the average score criteria (Pandiangan et al., 2017) as shown in Table 2.

Table 1:
Validity and Reliability of Learning Tools for Advanced Mathematics Courses

Learning Tools	Validity	Category	Reliability (%)	Category
Semester Learning Plans	3.72	very valid	92.87	Reliable
learning materials	3.73	very valid	93.35	Reliable
learning tools	3.79	very valid	94.77	Reliable

Table 2.
Assessment Criteria for Learning Model Validity

Score Interval	Assessment Criteria		Explanation
3.30<P<4.00	Very valid		Can be used without revision
2.30<P<3.30	Valid		Can be used with minor revisions
1.80<P<2.30	Less valid		Can be used with many revisions
1.00<P<1.80	Invalid		Cannot be used without revision and still requires consultation

The validity and reliability of the Semester Learning Plans, learning materials, and basic mathematics test kits were all categorized as very valid and reliable. Thus, the learning tools and Integral material test instruments in the Advanced Mathematics course were feasible and could be used in this study.

Before the learning was performed, a pretest on Integral material was given to both online and offline classes, and after the learning was completed, a posttest was given to each class. Both classes used the same learning tools and were taught by the same teachers.

To see if there was any difference in the progress of learning outcomes in the online and offline classes, the data on the pretest and posttest scores were collected and analyzed. The Normality and Homogeneity Test was done for the pretest to see whether the two classes were normally distributed. Homogeneous in variance and Difference test with independent t-test was done on the posttest is done to see if there was any significant difference between the two classes in the posttest results.

RESULTS

This study's findings regarding students' evaluation results is divided into two parts. The first is the quantitative results of the student's work, and the second is the analysis of the student's work.

Based on the results of the test scores on the Integral material before learning (pretest) and after learning (posttest) in both classes (online and offline), the average pretest and posttest scores are shown in Table 3.

Table 3.
Results of Pretest and Posttest in Online and Offline Classes

Online classes: N=31		Offline classes: N=34	
Pretest	Posttest	Pretest	Posttest
39.10	80.03	38.47	89

Table 3 shows that the results of the offline and online pretests are almost the same at 38.47 and 39.10. Meanwhile, the posttest results have an average value of 89 and 80.03. Furthermore, normality and homogeneity tests were carried out on the pretest data. The results are shown in Table 4.

Table 4.
Normality and Homogeneity Test on Pretest Data

Test of Normality

	Kolmogorov-Smirnov[a]			
	Group	Statistic	df	Sig.
Pretest	Online	.122	31	.200*
	Offline	.103	34	.200*

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Pretest	Based on Mean	12.862	1	63	.001

As seen in Table 4, the Online and Offline Groups come from a normally distributed population because the Online Group has a *P* value (Sig.) (0.378) > 0.05, while the Offline Group has a *P* value (Sig.) (0.772) > 0.05. For the homogeneity test, we found that the samples were taken from an inhomogeneous population because of the *p* value (Sig.) (0.001) < 0.05. Hence, the next step was to do a different test of the pretest results for the Online and Offline Groups using an independent *t*-test.

To strengthen the results of this data analysis, bootstrapping was performed on the pretest data. The results are shown in Table 5.

Table 5.
Normality and Homogeneity Test with Bootstrapping on Pretest Data

Test of Normality

		Kolmogorov-Smirnov		
	Group	Statistic	df	Sig.
Pretest	Online	.122	31	.703
	Offline	.103	34	.834

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Pretest	Based on Mean	12.862	1	63	.001

As seen in Table 5, after replicating the data 1,000 times, the data follows a normal distribution with an error degree of 0.05 for both Online and Offline Groups. The Online Group has a *p* value (sig.) 0.07 > 0.05 and the Offline Group has a *p* value (sig.) 0.834 > 0.05. This result aligns with the results before the data was replicated or bootstrapped 1,000 times and follows a normal distribution. In addition, Table 5 also shows the variance of the data, which is not homogeneous between online and offline methods. Therefore, if a test was carried out for the average difference in the results of advanced mathematics exams for students between the Online and Offline Groups, where the Online Group was given a test with Brilian apps and the Offline Group was given a written test, then we used the student *t*-test with different variances (Equal variances not assumed). However, to determine the effect of this treatment, we first tested the difference in the average results of students' mathematics exams in the pretest class. The results of the analysis are shown in Table 6.

Difference Test (Pretest Data)

Table 6.
Difference Test of Pretest Data

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Pretest	Online	31	39.10	13.410	2.408
	Offline	34	38.47	7.051	1.209

Independent Sample Test

		F	Sig.	t	df	Sig. (2-tailed)
Pretest	Equal variances assumed	12.862	.001	.239	63	.812
	Equal variances not assumed			.232	44.461	.817

Based on Table 6, we inferred that there was no significant difference between the pretest results between the Online and Offline Groups. This can be seen from the *P* Value (Sig.) (0.817) > 0.05, so we carried out the next stage, namely testing the difference in posttest results between the Online and Offline Groups.

Table 7.
Difference Test of Pretest Data with Bootstrapping

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Pretest	Online	31	39.10	13.410	2.408
	Offline	34	38.47	7.051	1.209

Independent Sample Test

		Mean Difference	Bias	Std. Error	Sig. (2-tailed) Lower	95% Confidence Interval	
						Upper	
Pretest	Equal variances assumed	-.626	-.06	2.697	.831	-6.245	4.681
	Equal variances not assumed	-.626	-.06	2.697	.834	-6.245	4.681

Table 7 shows the results of data analysis after bootstrapping 1,000 times. There is no significant difference in the mean advanced mathematics exam results for students between the online method and the offline method in the pretest class. The value can be seen from the *P* Value (Sig.) (0.834) > 0.05. In other words, the students' ability before being given treatment was the same between students with the online method and the offline method. Therefore, we carried out a follow-up test in the posttest class to provide information on whether the treatment improved student learning outcomes as reflected in the results of the mathematics exam. That value was also in line with the results without bootstrapping.

Difference Test (Posttest Data)

Table 8.
Difference Test of Posttest Data

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Posttest	Online	31	80.03	15.209	2.732
	Offline	34	89.00	8.453	1.450

Independent Samples Test

		F	Sig.	t	df	Sig. (2-tailed)
Posttest	Equal variances assumed	9.160	.004	-2.973	63	.004
	Equal variances not assumed			-2.900	45.965	.006

Based on Table 8, we inferred that there are significant differences between Online Group and Offline Group learning outcomes. This can be seen from the *P* Value (Sig.) (0.006) < 0.05.

In addition, there were differences in the work results of online and offline students. What is clear is that students take part in offline learning work in a coherent, step-by-step process according to what is given by the teacher in class, but students take part online learning work in a variety of ways. This difference is because online participants are used to developing literacy in cyberspace, while offline participants are more dependent on their educators (Singh et al., 2012).

Table 9.
Difference Test of Posttest Data with Bootstrapping

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Posttest	Online	31	80.03	15.209	2.732
	Offline	34	89.00	8.453	1.450

Independent Samples Test

		Mean Difference	Bias	Std. Error	Sig. (2-tailed) Lower	95% Confidence Interval	
						Upper	
Pretest	Equal variances assumed	8.968	-.133	3.135	.006	2.802	15.064
	Equal variances not assumed	8.968	-.133	3.135	.007	2.802	15.064

Based on Table 9, there was a significant difference in the average student mathematics exam results between the Online and Offline Groups after being given treatment, which can be seen from the *P* Value (Sig.) (0.007) < 0.05. This means that the treatment can improve student learning outcomes as reflected in the average advanced mathematics exam results, where student learning outcomes in the Offline Group are higher than those in the Online Group with a difference in average scores of 8.07, i.e., the Online Group obtained an average score for student mathematics exam results of 80.03, while the Offline Group was 89.00.

DISCUSSION

The pretest scores of the two classes before learning are quite low. This may be due to the fact that students do not understand the integral application materials in the business field, which are surplus consumers and surplus producers. After the learning was carried out, the scores in both classes increased. However, there is a significant difference in the increase between online and offline classes at the significance level of = 5% as shown in Tables 4, 5, and 6. These results are consistent with other research that stated there are

several factors that influence learning (Biswas & Dey, 2020; Sahoo et al., 2021).

The first factor is interaction in the classroom. This factor in online classes is very different from that of offline classes. According to Jaggars and Xu (2016), if educators in online classes do not seriously pay attention to their students, the students will pay less attention to the material because they do not deal directly with the educators. Of course, the same thing does not happen in offline classes, because direct interaction in the classroom allows educators to pay attention directly to their students.

The second factor is the educator's understanding of the media they use. This is certainly very influential, especially in online classes since the use of technology there is more complex than in offline classes (Eppard et al., 2019; Sakka et al., 2022).

The third factor is the facilities used by both educators and students, especially those related to technology. For those who take part in online learning, the strength of the network and the reliability of the supporting hardware to access the internet are very influential since, without adequate internet access, educators and students cannot properly accomplish the teaching and learning process. Research from Thongmak and Ruangwanit (2021) states that the intentions of students attending offline classes are different from the intentions of students attending online classes because offline classes are better able to increase student attendance than online classes. This is partly because students think that the learning equipment at school is more robust than the online equipment. Meanwhile, according to Singh et al. (2012), online classes are more suitable for students who are already working because they have more flexible time and good time management skills. On the other hand, offline classes are more suitable for full-time students. Research conducted by Nurfitri et al. (2022) also states that there are differences in learning outcomes between online and offline learning that are caused by differences in learning resources.

CONCLUSIONS AND SUGGESTIONS

Based on the research results and discussion above, we concluded that there are differences in learning outcomes between students who take online classes and offline classes. This is based on the fact that: (a) There is no significant difference between the results of the pretest between the Online and Offline Groups, which can be seen from the *P* Value (Sig.) (0.817) > 0.05, and (b) There is a significant difference between the online and offline posttest learning outcomes as can be seen from the *P* Value (Sig.) (0.005) < 0.05.

Based on the results obtained, further research can be conducted on how to create a learning model for Advanced Mathematics courses that can combine online and offline learning in balanced proportions. This should improve student's learning outcomes, considering that currently offline learning is possible without leaving online learning. After the learning model is created, it must be equipped with suitable teaching tools.

From the results of the study, it can be seen that there are differences in the results of the online class and the offline class, both in terms of grades and performance analysis. This difference is due to the different learning processes between online and offline.

LIMITATIONS

This research is limited to an Information Systems Study program class, so it must be expanded to other study programs, bearing in mind that using information technology also affects the results. The next step would be to conduct research in the Product Design study program for the mathematics design course to know whether they have the same results because the nature of science material is different. This means the same system would be used in a wider range of courses.

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