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THE EFFECTIVENESS OF HYBRID LEARNING ON STUDENT LEARNING OUTCOMES IN NUMBER THEORY

(PENGARUH PEMBELAJARAN HIBRYD TERHADAP HASIL BELAJAR MAHASISWA PADA TEORI BILANGAN)

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Abstrak

Pada tahun 2022 kasus COVID-19 mengalami penurunan yang signifikan dibandingkan tahun 2021 sehingga menyebabkan berbagai lembaga baik sekolah maupun perguruan tinggi mempertimbangkan untuk dapat menyelenggarakan pembelajaran tatap muka. Pembelajaran hybrid merupakan model pembelajaran terkini di masa pandemi dan memadukan teknologi terkini. Pembelajaran daring kemudian dilanjutkan dengan metode konvensional (luring). Penelitian ini bertujuan untuk melihat efektivitas pembelajaran hybrid terhadap hasil belajar mahasiswa pada mata kuliah teori bilangan. Metode penelitian yang digunakan adalah penelitian eksperimen semu. Populasi dalam penelitian ini adalah seluruh mahasiswa semester genap tahun ajaran 2021/2022. Sampel yang diambil berasal dari dua kelas dengan jumlah keseluruhan 35 mahasiswa. Teknik pengambilan sampel yang digunakan adalah purposive sampling berdasarkan pertimbangan dosen teori bilangan, analisis data menggunakan software SPSS, dan menggunakan uji-t sampel independen. Berdasarkan hasil perhitungan analisis data menggunakan SPSS, pembelajaran hybrid terhadap hasil belajar mahasiswa teori bilangan dengan menggunakan pembelajaran konvensional tidak efektif. Pembelajaran hybrid tidak dapat dijadikan model pembelajaran alternatif di era pasca pandemi COVID-19 karena pembelajaran hybrid tetap menggunakan pembelajaran konvensional, meskipun diawali dengan pemanfaatan teknologi seperti pembelajaran daring.

Kata Kunci: Hasil belajar, Matematika, Teori Bilangan, Pembelajaran Hybrid

Abstract

In 2022, cases of the COVID-19 virus have significantly decreased compared to 2021, and this has caused various institutes, both schools and universities, to consider being able to learn face-to-face. Hybrid learning is the latest learning model during the pandemic and integrates the latest technology. Learning online and then continuing with conventional methods (offline). This research aims to see the

effectiveness of hybrid learning on student learning outcomes in number theory. The research method used is quasi-experimental research. The population in this study were all even-semester students in the 2021/2022 semester 2. The samples taken were from two classes with 35 students. The sampling technique used was purposive sampling based on considering the number theory lecturer, data analysis using the Software SPSS, and using the independent sample t-test. Based on the results of data analysis calculations using SPSS, hybrid learning on number theory student learning outcomes using conventional learning is not effective. Hybrid learning cannot be used as an alternative learning model in the post-pandemic COVID-19 era because hybrid learning still uses conventional learning, even though it starts with using technology such as online learning.

Keywords: *Hybrid Learning, Number Theory, Mathematics, Students' Learning Outcomes*

INTRODUCTION

As technology develops, there will inevitably continue to be changes in learning in the field of education. The COVID-19 pandemic has made researchers find the right way to continue improving students' mathematical abilities at the school and university levels. The existence of the COVID-19 virus causes humans to be creative in creating technology to help the process of educational activities in Indonesia without having to meet face-to-face. Currently, online learning is still used in schools and universities. The rapid change in face-to-face and online learning methods makes it difficult for students/lecturers to deliver and receive the course material being studied. Many difficulties are found in online learning, including incomplete facilities and infrastructure, internet instability, quota costs, and many other factors. Technology is increasingly creating various platforms to help the teaching and learning process. Many studies have tested the effectiveness of the platform during online learning, including Google Classroom, psychology, Moodle, Zoom meetings, Google Meet, Edmodo, and other platforms. As time goes by, learning is also being refined to produce better quality than before.

The hybrid learning model is the current learning model during the COVID-19 pandemic and has been integrated into technology. Hybrid learning combines offline and online learning (Haeruman et al., 2021). Many say that hybrid learning and blended learning are the same learning model (Fauzan & Arifin, 2017; Indarto et al., 2018; Sari & Yarza, 2021), namely the combination of electronic learning (e-learning) with conventional learning (face-to-face) using various platforms or Learning Management Systems (LMS). According to (Fauzan & Arifin, 2017), Hybrid Learning is very easy to implement because it is a combination of conventional learning (synchronous) and internet-based learning (asynchronous). Combining web-based learning and face-to-face methods simultaneously in learning is called hybrid learning (Fauzan & Arifin, 2017), The hybrid learning model was chosen because it combines problem-based learning modified with the Science, Technology, Engineering, and Mathematics (STEM) approach and uses an e-learning system in learning (Aristika et al., 2021). The hybrid learning model can build and develop advanced mathematical thinking because it can provide opportunities for students to represent and abstract

mathematical concepts that are understood in learning, and provide opportunities to prove the theories they have understood and help them add and correct failures in the process (Aristika et al., 2021).

Based on the research results (Karnawati & Istianingrum, 2021) that there is no significant difference between learning outcomes using hybrid learning and flipped classrooms in Japanese language learning. In research (Hermawan et al., 2019) These hybrid learning methods is quite effective in improving the understanding and grades of students participating in Clinical Chemistry and Bioanalysis courses. This follows the results of research (Karnawati & Istianingrum, 2021) that hybrid learning is more effective because the percentage of effectiveness is higher in improving learning outcomes than in flipped classrooms in chunky bunpou courses for fourth-semester students of Japanese Language Education. Based on the results of previous research, there is no related research on the effectiveness of hybrid learning on learning outcomes in number theory.

Number theory is a compulsory course that must be taken by students of the mathematics education study program at the Muhammadiyah Prof. Dr. HAMKA University in the even semester, namely semester two. With a weight of two credits, students can understand and apply number theory in everyday life, such as modulo calculations, congruence, Fermat, greatest divisor, and so on. Many studies have analyzed mathematical abilities in number theory courses, including analysis of understanding ability, proof ability, and problem-solving ability in number theory courses (Nurrahmah & Karim, 2018; Setiawan et al., 2021) and research related to the development of number theory teaching materials (Handayani et al., 2021) as well as the application of number theory teaching materials, 2021) and the application of learning using Edmodo (Zargany et al., 2019) and its relation to students' practical attitudes, namely self-confidence and parental parenting in number theory courses (Tisngati & Meifiani, 2014) and the effectiveness of response to learning outcomes in number theory (Ardiawan, 2016). The gap and novelty in this research are the relationship between the latest learning model in the post-pandemic COVID-19 era and student learning outcomes in number theory. Is hybrid learning an effective learning model applied to number theory courses in the post-pandemic COVID-19 period, so that there is an effect of the hybrid learning model on student learning outcomes in number theory? This research focuses on hybrid learning using synchronous and asynchronous, namely the use of Zoom meetings for synchronous and Online Learning at UHAMKA

LITERATURE REVIEW

Hybrid Learning in Education

Hybrid learning is the latest learning model after the emergence of COVID-19. This learning combines face-to-face learning and online learning. Many experts define hybrid learning, including Kosar (2016), who defines hybrid learning as the arrangement of various instructional modalities, delivery media, teaching methods and web-based technology. Meanwhile, according to Hall & Villareal (2015), it is a combination of face-to-face and online course formats available to all students in learning. And according to Sorden (2012), hybrid

learning is not just a combination of face-to-face and online learning, but a combination of training methodologies that use the best delivery methods to achieve learning goals.

Hybrid learning, often interchangeably used with terms such as blended learning, represents a pedagogical approach that combines traditional face-to-face instruction with online learning elements to create a flexible and student-centred learning environment. The integration of both modalities is intended to maximise the strengths of each, offering opportunities for interaction, collaboration, and autonomous study.

According to Kosar (2016), hybrid learning significantly enhances student engagement and academic performance by leveraging digital resources alongside conventional classroom teaching. Kosar's study on English language learning at the university level highlights that hybrid instruction allows students to access learning materials anytime and anywhere, supporting independent practice while still benefiting from direct teacher guidance during in-person sessions.

Similarly, Hall and Villareal (2015) explored graduate students' perceptions of hybrid courses and concluded that hybrid learning offers a unique advantage by promoting flexibility without sacrificing the social and collaborative elements of traditional education. Their research emphasises that students perceive hybrid courses as more accessible and adaptable to their schedules, yet equally rigorous compared to fully face-to-face formats.

The theoretical foundation for hybrid learning is supported by Sorden (2012) through the lens of

Cognitive Theory of Multimedia Learning (CTML). Sorden argues that the combination of multimedia presentations and face-to-face interaction facilitates deeper understanding by reducing cognitive overload and encouraging the construction of meaningful knowledge representations in learners. Additionally, Graham (2013) asserts that hybrid learning is not merely a logistical solution but a transformative practice, capable of reshaping the way knowledge is delivered and constructed. The design of hybrid courses encourages a shift toward active learning environments where students can engage in critical thinking, collaborative problem-solving, and real-time feedback both online and offline.

Recent studies also highlight the relevance of hybrid learning in developing 21st-century skills, particularly during disruptions such as the COVID-19 pandemic, where flexible learning models proved essential. Garrison and Vaughan (2008) introduced the Community of Inquiry (CoI) framework to further enhance the hybrid learning experience, focusing on the interplay between cognitive presence, social presence, and teaching presence in blended environments.

In conclusion, hybrid learning represents an effective instructional approach that blends the best features of online and traditional methods. Its success, however, hinges on thoughtful instructional design, technological support, and clear alignment with learning outcomes.

Students' Learning Outcome: Number Theory

The Number Theory course is a fundamental part of mathematics education, which not only introduces basic concepts such as divisibility, prime numbers, and congruence, but also develops students' logical thinking skills and

conceptual understanding. According to Anisah and Lastuti (2023), students' conceptual understanding in the Number Theory course is in the "good" category with an average score of 64.75. This study shows that although students have a solid basic understanding, there is still room for improvement, especially in applying these concepts in more complex contexts.

Other sources, such as the syllabus from the Illinois Institute of Technology (2004), emphasise that the learning objectives in this course include mastery of the basic definitions and concepts of Number Theory, the ability to apply core theorems, and skills in writing mathematical proofs. This shows that the expected learning outcomes are not only limited to theoretical understanding, but also to practical abilities in problem solving and proof. Furthermore, Campbell and Zazkis (2002) in their work "Learning and Teaching Number Theory" highlight the importance of teaching strategies that pay attention to students' learning styles and cognitive strategies. They emphasise that the use of visual representations and connections to real-world experiences can enhance the understanding and application of Number Theory concepts.

In addition, the learning materials from OpenLearn (2023) list specific learning outcomes that include the ability to find the quotient and remainder of the division of integers, apply Euclid's algorithm, understand the definition of congruence, and perform modulo n arithmetic operations. This suggests that learning outcomes in Number Theory are designed to provide students with skills that can be applied in a variety of contexts, including cryptography and information theory.

The Implementation of hybrid learning to students' learning outcomes

Hybrid learning, which combines face-to-face learning with online learning, has become a popular approach in higher education, especially after the COVID-19 pandemic. This model aims to combine the advantages of both learning methods to improve student learning outcomes. A study by Al Hosani (2024) conducted a meta-analysis of 50 studies published between 2015 and 2021, finding that hybrid learning has a significant impact on students' academic success, especially in science. However, its effectiveness is influenced by variables such as education level and discipline.

A study by Syawaluddin et al. (2024) highlighted that hybrid learning increases student engagement by providing a flexible learning environment. However, its effectiveness in improving academic performance varies depending on students' access to technology, self-discipline, and time management skills. Albeta et al. (2023) in their systematic review concluded that hybrid learning can improve learning outcomes, classroom dynamics, and positive perceptions from students and teachers. However, challenges such as limited interaction and difficulty in monitoring student progress online remain concerns. Raes et al. (2020) in a systematic literature review on synchronous hybrid learning found that this model creates a more flexible and engaging learning environment compared to fully online or face-to-face instruction. However, pedagogical and technological challenges need to be addressed to optimise student learning outcomes.

RESEARCH METHODOLOGY

This research is quantitative and uses experimental methods. The form of research used in this research is a quasi-experimental design (Sugiyono, 2016). The design used is a posttest-only Control Group Design, which includes a control group as a comparison (Sugiyono, 2016). The population in this study were all second-semester mathematics education students at Prof. Dr. HAMKA Muhammadiyah University (class of 2021). The sampling technique uses purposive sampling based on specific objectives. The sample was obtained from classes, Class B and Class C. Class B consists of 18 students, and Class C consists of 19 students. In determining the experimental class and control class, it was chosen randomly by the researcher. So, class C is the experimental class, namely, using hybrid learning, and class B is the control class, namely, the use of conventional learning.

The research instrument consists of students' learning outcomes after taking 1 semester of number theory courses, from the results of students' final exams. This question is in the form of an essay with 5 questions and the content has been validated by the quality assurance agency for mathematics education study programs. The data collection technique used in this study is a measurement technique with a data collection tool, namely, a number theory learning outcomes test instrument. Data analysis techniques are needed to test the research hypothesis. Before the hypothesis test is carried out, a prerequisite test is carried out, namely the normality test and the homogeneity test. The normality test uses the Shapiro-Wilk test because the data is small, namely 35. Then, the significance value must be more than 0.05, then the data is normally distributed. If it is not normally distributed, there is no need to do a homogeneity test and directly use a non-parametric test, namely the Mann-Whitney test. For the homogeneity test, the test uses the F test or Levene test, and the significance value must be more than 0.05; then both datasets are homogeneous. The formulation of the statistical hypothesis for the test of the difference between the two means of student learning outcomes data with a one-sample test is

$H_0 : \widehat{\mu_1} = \widehat{\mu_2}$
There is no significant difference between the learning outcomes of hybrid learning class students and conventional classes.

$H_0 : \widehat{\mu_1} > \widehat{\mu_2}$ The learning outcomes of hybrid learning class students are significantly better than those of conventional students.

The data analysis technique used in this study is a two-sample t-test using SPSS 21 software. Below is a chart of Data Analysis procedures.

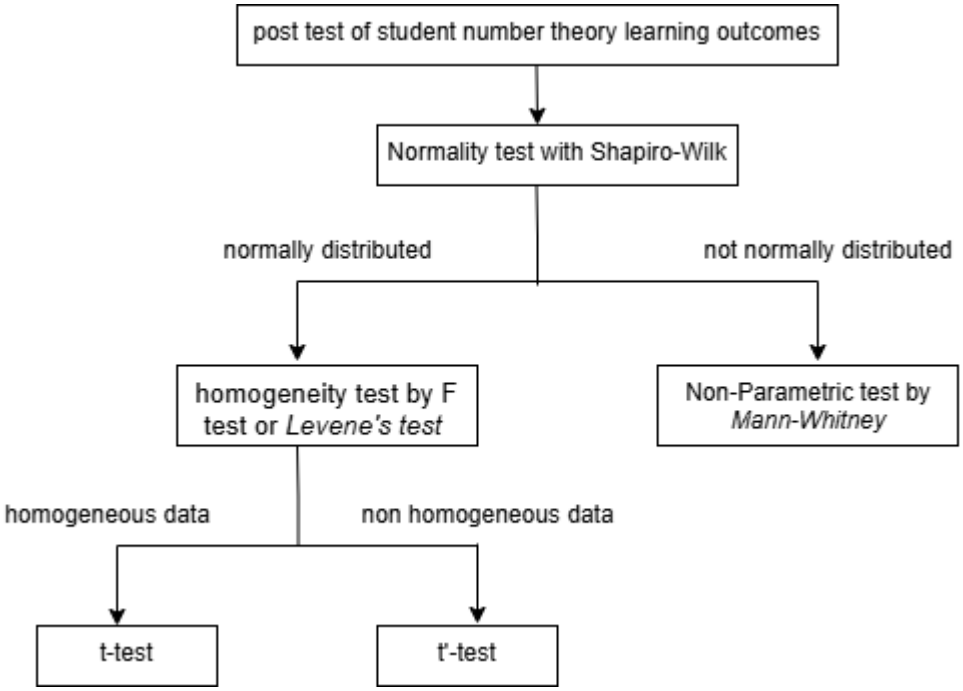

Figure 3: Chart of Data Analysis Procedures

RESULTS AND DISCUSSION

Statistical tests were conducted to show descriptive statistics of the number theory student learning outcomes in groups. The results are in Table 1.

Table 1. Descriptive Statistics

Statistik deskriptif	Hybrid Learning	Conventional Learning
n	19	18
Min	45	25
Maks	100	100
Rata-rata	78.94	79.5
Standard Deviasi	19.5	15.77

In general, the minimum score of a hybrid learning class is higher than that of a conventional class. Next is the normality result using the Shapiro-Wilk test and homogeneity using the Levene test. The results can be seen in Tables 2 and 3.

Table 2. Normality Test Results of Number Theory Student Learning Outcomes

Outcomes	Class	Statistic	df	Sig.
Learning	Hybrid Learning	.871	19	.015
students	Konventional	.746	18	.000

The normality test results reveal the Sig value: Experimental class = 0.015 and Sig control class = 0.000. The two classes have a Sig value of less than 0.05,

which indicates they are not normally distributed. Because the data is not normally distributed, the non-parametric test immediately uses the Mann-Whitney test.

Table 3. Man, Whitney test results: Test Statistics

Test Statistics

	hasil
Mann-Whitney U	164.000
Wilcoxon W	335.000
Z	-.214
Asymp. Sig. (2-tailed)	.831
Exact Sig. [2*(1-tailed Sig.)]	.845[b]

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

Based on the results of non-parametric tests using Mann-Whitney, the result of 0.415 is more than 0.05, meaning that there is no difference in student learning outcomes between hybrid learning and conventional learning. Thus, hybrid learning is ineffective in number the student learning outcomes.

Based on the results of the data analysis presented previously, the following will describe the description and interpretation of the research data. The description and interpretation of research data were analysed based on student learning outcomes in number theory. Based on statistical results, the average conventional learning outcome is higher than the average learning outcome of hybrid learning classes. It was obtained that the average learning outcomes of conventional classes and hybrid learning classes were 79.5 and 78.9, respectively. However, the average of the two classes is only slightly different, 0.6, because the hybrid learning class has more students than the conventional class. After further analysis with the average difference test, namely the non-parametric test with the Mann-Whitney test, it was found that there was no difference in student learning outcomes between hybrid learning classes and conventional classes. In hybrid learning classes, students can use technology well, and it is integrated by online learning Uhamka (OLU) when practising questions on number theory.

This is the opinion (Ganovia et al., 2022) that activities in hybrid learning have many obstacles. This is due to the results of research (Simarmata et al., 2022) that using hybrid learning has only 13.2% on students' mathematical abilities, meaning that hybrid learning has a minimal impact on students' mathematical abilities in the learning process in number theory courses. Number theory is the basis for further courses such as fundamental analysis courses, algebraic structures, complex analysis, and others. This research implies that hybrid learning is an alternative to learning innovation during the post-pandemic COVID-19 period. Hybrid learning provides opportunities for lecturers and students to represent and abstract the mathematical concepts they understand, and provides opportunities to prove the concepts they have understood, especially in courses.

CONCLUSION AND SUGGESTION

Based on the results and discussion above, it can be concluded that there is no difference in learning outcomes in number theory using hybrid learning with conventional learning. Thus, hybrid learning does not affect learning outcomes in number theory.

suggestions for further research are to link it with other mathematical abilities such as problem solving and 21st century abilities and for learning outcomes the hybrid learning method is not recommended because it has no influence on the learning outcomes of number theory. this proves that one of the shortcomings of hybrid learning is that it cannot influence the learning outcomes of students' number theory at university.

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