



The Effectiveness of Hybrid Learning in Improving of Teacher-Student Relationship in Terms of Learning Motivation

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Abstract

The Advanced Mathematical Thinking (AMT) ability is one of the prioritized mathematical abilities needed to be developed in learning mathematics during tertiary education. The present study sought to test the effectiveness of hybrid learning in improving students' advanced mathematical thinking. The research used a quasi-experimental design with a non-equivalent control group design. The subject of this study was students of a mathematics education study program at a university in Bandung who attended lecture for the multi-variable in a calculus course. The sampling technique used was purposive sampling. Of the many variable calculus classes consisting of 2 classes, one class was chosen as the experiment group and the other class as the control group. The sample consists of 40 people for each group. Data analysis used the MANOVA test with normality and homogeneity tests as a prerequisite test. The results showed a difference in AMT's significance between the hybrid learning and conventional groups, where hybrid learning had a higher AMT. Other than that, there is a difference in the significance of AMT between the high motivation group and the low motivation group, where high motivation has a higher AMT, and there is an interaction of learning models and motivational factors to increase AMT.

Keywords:

Hybrid Learning;
Advanced Mathematical Thinking;
Learning Motivation;
Statistical Analysis;
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1- Introduction

Advanced Mathematical Thinking (AMT) is a mathematical thinking process that includes of representation, abstraction, the relationship between representation and abstraction, creativity, and mathematical evidence [1, 2]. AMT ability is one of the priority mathematical abilities to be developed in mathematics learning in tertiary institutions. However, based on the results of a survey conducted by Tall in the Tennessee University of Technology students who have passed the calculus course it turns out that not one student is able to answer the questions correctly [3]. In addition, Watson has also tested new students who excel in high school and found many misconceptions about mathematical concepts [4]. This is because students tend to experience difficulties in obtaining the essence of abstract mathematical concepts and difficulties in constructing the expected general form [5].

The first problem faced by students is their AMT ability of representation. Representation can help students understand, communicate, and relate mathematical concepts in various forms [6]. The problem of representation can be seen from students who tend to use symbolic representations without paying attention to other forms of representation [7]. Hutajulu and Minarti show that most students still have difficulty using various mathematical representations to explain mathematical ideas and solve mathematical problems [8]. The next problem is an abstraction which is a fundamental process in the form of mathematics. According to Dreyfus, abstraction and representation are two

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complementary processes [9]. Mathematical concepts are often abstracted from several forms of representation [10]. Vice versa, the form of representation is also often expressed from several more abstract mathematical concepts [11]. Even so, abstraction turns out to be one of the causes of students failing in the mathematics learning process [12]. It is because students tend to have difficulty obtaining the essence of abstract mathematical concepts [13]. Likewise, Cribbs (2013), said that students generally still experience difficulties in constructing the expected general form [14].

Apart from representation and abstraction, students are also required to think creatively [15]. Creative thinking is seen when someone can judge something from a different point of view. However, students' creative thinking skills are still low. That opinion is supported by the findings of Herlina and Batusangkar (2015) in mathematics education program students at universities in Kalimantan and Jakarta who still experience difficulties if given divergent and nonroutine question forms [16]. The following skill in Advanced Mathematical Thinking is proof [17]. Learning mathematics requires proof because mathematics is a science that uses axiomatic deductive reasoning so that evidence has a significant position in mathematics. However, the proof is a mathematical process that is considered difficult by students [18, 19]. The difficulty of students in constructing evidence is caused by: (1) students do not understand definitions, (2) students have limited intuition related to concepts, (3) mathematical concepts that students have are not sufficient to construct evidence, (4) students are not able to construct an example of its own to clarify the evidence, (5) students do not know how to use the definition to construct complete evidence, and (7) students do not know the technique to initiate the mathematical proof process (Moore in Suryana) [20]. Various studies show that students' Advanced Mathematical Thinking is still low [21-26].

The results of a study conducted by Davis concluded that students were not able to solve problems that required creative ideas [27]. Meanwhile, Arnawa (2006), in their study stated that students have difficulty in constructing mathematical evidence, especially in starting the proving process and linking the concepts they have with the elements of the conclusions to be proven [4, 13, 28-30]. The survey results indicate that developing Advanced Mathematical Thinking's ability to solve problems is necessary to model appropriate learning [31]. The learning model must be active and support student involvement in understanding concepts and creative thinking in calculus courses. The selection of the chosen learning model must be able to accommodate student characteristics in terms of student conditions, type of material, depth, scope, order of presentation, and treatment of learning material. So, in this study, the researchers chose to apply the hybrid learning model [32].

The hybrid learning model is an innovative learning model that utilizes information and communication technology [33]. The Hybrid Learning model has developed around 2000 and has been used in several countries: North America, England, Australia, universities, and training institutions. This learning model has several advantages: using learning technology such as computer media, iPhone, TV, video conferencing, images and sound, multimedia presentations, weblogs, and social media [34]. According to Jamison et al. (2014) hybrid learning is a process of acquiring knowledge and skills (learner centered) that is developed with an instructional design that integrates digital (internet and mobile), printed, recorded, and traditional face-to-face class activities in a planned, practical pedagogical way [35]. Hybrid learning also facilitates students to direct their own learning process by choosing methods with available learning materials that best suit their individual characteristics and needs-oriented towards achieving curriculum learning goals. Adnan and Bahri (2018) emphasized that hybrid learning is a learning model that integrates innovation and technological advances through an online learning system with the interaction and participation of traditional learning models [1].

Learning designed with a hybrid learning approach also makes it possible to influence students' metacognitive awareness [36]. Hybrid learning has advantages because, in addition to using a face-to-face approach, this approach also uses ICT, both mobile and nonmobile technology. This innovation can increase the effectiveness of teaching and learning [16, 37]. The use of the internet must be integrated into the higher education system [38]. Indonesian Ministry of Research and Higher Education. Learning with the help of computers can improve the interactive and communicative aspects [39]. The learning model that utilizes the use of technology is hybrid learning. Hybrid learning combines the process of delivering learning content online, offline, mobile with regular face-to-face learning effectively [40]. Hybrid Learning is an approach that seeks to incorporate the best benefits of "old" and "new" teaching methods so that the quality of learning developed is the optimal quality that is better than face-to-face quality or just online learning activities online [8].

Several research results conducted by Bowen et al. (2013) found that the hybrid learning model can improve students' mathematical abilities and student learning outcomes [7]. In learning mathematics, a teacher presenting learning with a hybrid learning model must pay attention to several requirements, namely that he must master and know developing IT [41]. In addition, the teacher must also have teaching skills, present face-to-face learning content, and have knowledge and skills in developing computer-based learning resources. In designing mathematics learning using a hybrid learning model, it also needs to be set those students can study anywhere, anytime, and with anyone (for example, students can study with teachers, experts, friends, family, community) through various learning resources such as textbooks, internet, CD rooms, radio, tapes, TV, and others. The exciting thing about this hybrid learning system is that it combines two kinds of choices, which will play a significant role in the lecture process, namely instructor-led or student-led (learner-led) [35].

Currently, the development of hybrid learning is very much, all of which come from the combination of one or more models, methods, or media. Several hybrid learning is currently being developed in Indonesia, such as face-to-face lectures, synchronous virtual collaboration, asynchronous virtual collaboration, and self-pace asynchronous [42]. The implementation of these hybrid learning models is carried out with several cycles and meetings. Thus, students will learn something different and new to be analyzed and studied. It will spur students to think critically because of the demands for independent learning when running online classes [43].

One of the materials developed by researchers to be able to be hybridized in the multivariable calculus course. This material is an abstract concept based on principles. The hybrid learning model has various ways in terms of its application, and educators agree that with the developing hybrid learning model, many educators, such as the team, will create an online environment for their students [44]. Although this model is relatively new, its goal is similar to other educational innovations: "to help teachers achieve what they strive for every day by understanding deeply and enabling every student they work with to achieve very high levels of educational mastery [45].

The hybrid learning model in this study was chosen because it combines problem-based learning modified with an approach Science, Technology, Engineering, and Mathematics (STEM) and using the eLearning system in learning. This hybrid learning model aims to provide opportunities for prospective teachers to increase creativity and representational abilities in concept mastery by applying the Project-Based Learning model and the STEM approach used by Rush and combined with the use of Edmodo application in teaching prospective teachers [46]. Edmodo app is a social media application that has more functions to help lecturers manage a system that provides features to connect students and manage student activities easily [47]. The researcher uses a syntax consisting of three stages in the hybrid learning model: seeking information, acquiring information, and synthesizing knowledge. These stages have been modified and adjusted to the needs of prospective teachers who will get treatment [48].

In addition to the learning model, another factor that affects mathematics learning outcomes that comes from within students is student learning motivation. Motivation plays an essential role in providing passion or enthusiasm for learning [49]. With learning motivation, especially learning mathematics, students will have a mental urge to do mathematics learning activities to achieve specific goals. Motivation to learn appears characterized by feeling. In learning activities, if a student has emotions, acts, or has a strong desire to learn so that there is a change in the energy in him, the student can learn [50]. On the contrary, if students do not do what they should and are not interested in studying. It means that students do not change energy, have no motivation [51]. Efforts that must be given are in the form of stimulation in order to grow motivation in students. In the learning process, a teacher is expected not only to be able to provide knowledge only by conveying information so that students become passive but it is also hoped that the teacher can actively involve students in building knowledge in their minds, providing support and opportunities for students to develop their ideas in learning. Learning outcomes are determined by the learning motivation of students [52].

Advanced mathematical thinking needs to be owned by students to understand the concept of Multivariable Calculus. It is because Multivariable Calculus is one of the courses that have the characteristics: (1) the material is abstract, (2) requires the ability to generalize and synthesize, (3) emphasize the aspects of deductive reasoning/proof, (4) require understanding analytically and geometrically, and (5) requires creative ideas.

From some of the research results, learning with a hybrid learning model with its syntax has a positive impact on improving the mathematical abilities of mathematics students. It is possible because learning with a hybrid learning model can facilitate and provide opportunities for students to seek, find and build knowledge to solve various problems, create a relaxed and conducive learning atmosphere, provide opportunities for students to extract various information from all sources optimally. Therefore, learning with a hybrid learning model should continue to be developed and used to choose teachers or lecturers in mathematics learning.

2- Theoretical Review

2-1-Advanced Mathematical Thinking (AMT)

Advanced Mathematical Thinking is an ability that includes representation, abstraction, connecting representations and abstractions, creative mathematical thinking, and mathematical proving [53]. Learning at the basic level of mathematics has now begun to be presented in the form of open problems so that advanced thinking processes are not only found at the university level. AMT has become the center of attention in the development of thinking skills at this time. AMT is thought in advanced mathematics or advanced thinking in mathematics. Many experts have discussed a lot about advanced mathematical thinking, such as Dreyfus [42, 54, 55]. The definition of advanced mathematical thinking is based on the difference between the way of understanding and the way a person thinks. In addition, advanced mathematical thinking also uses the opinion expressed by Juteau (2019) about epistemological ideas and obstacles involved in the development of advanced mathematical thinking [56].

Pedagogically, AMT refers to Dubinsky: (1) The meaning or interpretation of the relationship between concepts, statements, or problems; 2) a specific solution someone provides to a problem; 3) Special proof that someone offers to

prove mathematically. The way of thinking of someone whose advanced mathematical thinking develops has three interrelated categories: beliefs, problem-solving approaches, and proof schemes. The proof scheme includes a person's method of justifying. Fernández et al. (2012) proof and justification are used interchangeably [19]. The transformational features of proof schemes:

- Consideration of general aspects of conjecture,
- Application of goal-oriented and anticipatory mental operations in the attempt to predict outcomes based on general principles and
- Transforming images that govern deduction in the evidentiary process.

At the University level, teaching always begins with proof. The proof is seen as part of the problem-solving process, which is the final stage of mathematical activity where ideas are made precisely. Unfortunately, most students at the advanced level have difficulty in proving [57]. Some students usually only think of relying on empirical observations to justify a mathematical argument, but it is wrong that a student should find the right solution to solve problems and generalize mathematical ideas [58]. Therefore, researchers want to develop students' advanced mathematical thinking abilities to change the way students' understanding and thinking are more focused [59].

Table 1. Mathematical Thinking.

Indicator	Information
Representation	1) Revealing mathematical ideas; 2) Communicating work results in a certain way as a result of the interpretation of his thoughts, such as arithmetic symbol representation; language or verbal representations, and image or graphic representations.
Abstraction	1) Generalizing and generating/inducing specific forms in mathematical concepts to be able to identify their similarities; 2) Synthesize / combine parts of mathematical concepts to form a whole.
Mathematical Creative Thinking	1) Fluency: generates lots of ideas in various categories; 2) Originality: have new ideas; 3) Elaboration: solve the problem in detail.
Construct mathematical proof	1) Construct the evidence that has been obtained from mathematical concepts; 2) Validating the evidence that has been obtained

2-2-Hybrid Learning

Hybrid learning or blended learning is learning that combines all forms of learning, for example online, live, and face-to-face (conventional) [60]. Then hybrid learning can be explained as defined as a combination of face-to-face learning methods in the class-room with the material provided online [61, 62].

Although the hybrid learning model has various ways in terms of its application, educators agree that with the developing hybrid learning model, many educators, such as the Team, will create an online environment for their students [63]. Although this model is relatively new, its goal is similar to other educational innovations: "to help teachers achieve what they strive for every day by understanding deeply and enabling every student they work with to achieve very high levels of educational mastery" [64]. However, the researchers say that the hybrid learning model has the potential to provide transformative experiences where a new mode of Education can challenge teachers to innovate to implement the best way to educate their students [65].

Blended learning uses a technological approach and a combination of learning resources to start or continue face-to-face learning [66, 67]. With blended learning, students have the opportunity to learn independently, develop, and sustainably throughout their lives. From some of the research results, learning with a hybrid learning model with its syntax has a positive impact on improving the mathematical abilities of mathematics students [68, 69]. It is possible because learning with a hybrid learning model can facilitate and provide opportunities for students to seek, find and build their knowledge to solve various problems, create a flexible and conducive learning atmosphere, provide opportunities for students to extract various information from all sources optimally. Therefore, learning with a hybrid learning model should continue to be developed and used to choose teachers or lecturers in mathematics learning [70].

Learning with hybrid learning that integrates E-learning into learning also has many advantages such as: (1) students are more motivated to learn with the support of E-learning; (2) activity and involvement students are higher because using E-learning, learning is more interactive and challenging; (3) ICT provides a very broad potential source of information; (4) ICT can visualize complex models so that it makes understanding easier; (5) can perform repetitive

tasks quickly and accurately (6) can display learning designs that are more creative, interactive and innovative; (7) the learning process can transcend time and space [9].

2-3- The Didactic Triangle

The teaching situation can be analyzed and described in its three main components: students, teachers, and content. Entities and interactions between teachers and students can be illustrated in a didactic triangle, as shown in Figure 1 [71].

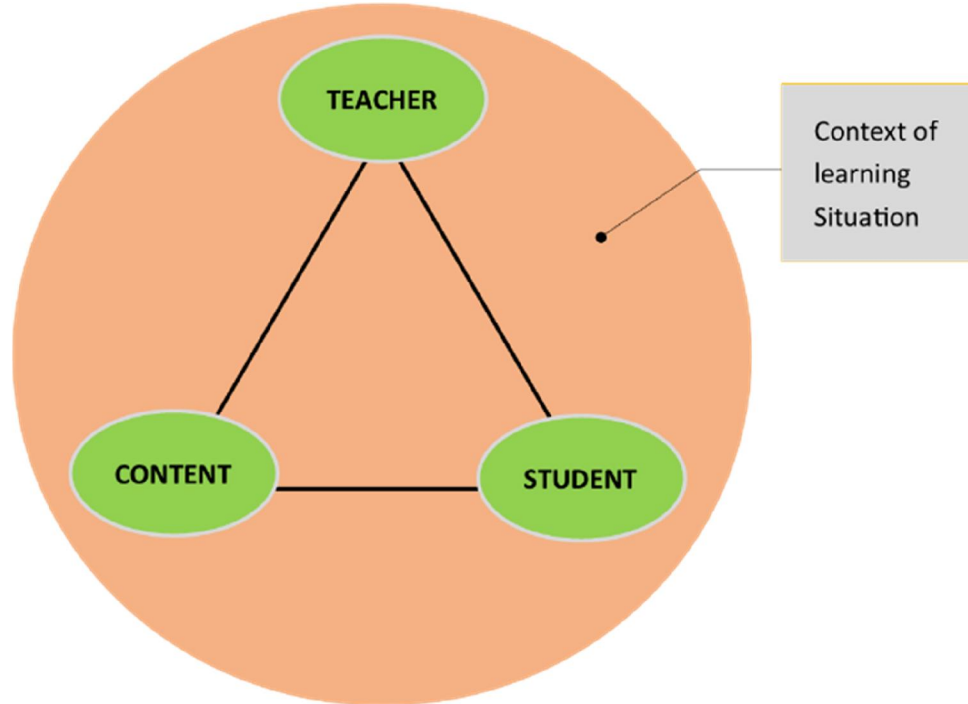


Figure 1. Didactic triangle.

The didactic triangle is a heuristic that identifies the fundamental component of the didactic system, including teachers, students, and learning content. Naturally, among these three components, the subject-specific didactic pays special attention to analyzing subject content to develop an effective presentation and sequence of such content for teaching and learning purposes [72].

In the didactic triangle, the teacher plays a role in creating a didactic situation so that the learning process occurs in students [56]. It indicates that the teacher must master the teaching material, learn about students, and create didactic situations to optimize learning. It is from now on known as the didactic relation.

Didactic and pedagogical situations are very complex, so teachers must have the ability to perceive this comprehensively, identify and analyze essential things that happen, and take appropriate actions for optimal learning [73]. This ability is, from now on, referred to as metapedadidactic.

Metapedadidactic consists of three essential components, namely unity, flexibility, and coherence or logical linkage [74]. Unity means that the teacher can see the modified didactic triangle sides as something intact. Flexibility is the anticipation that the teacher has prepared according to didactic and pedagogical. Coherence means a didactic situation that develops in each milieu until different situations arise, so the differences in these situations must be managed so that changes in the situation during the learning process run smoothly and lead to achieving goals [75].

2-4- Application of the Hybrid Learning Model in improving Advanced Mathematical Thinking

Advanced mathematical thinking is very much determined by the initial mathematical abilities that students have before. It can be understood that a person obtains concepts such as concept formation and assimilation concept. Concept formation is an inductive process, while the acquisition of concepts is an inductive process. Inductive and deductive processes are the basic things that affect the ability to think advanced mathematical thinking. The student-centered learning process can develop advanced mathematical thinking abilities because students can build their knowledge. The stages of the hybrid learning model that improve the advanced mathematical thinking of prospective teacher students are listed in Table 2.

Table 2. Stages of Hybrid Learning.

Hybrid Learning Stages	Lecturer activities	Student activities	Advanced Mathematical Thinking
<i>Phase 1 seeking of information</i>			
Reflection	<ul style="list-style-type: none"> Lecturers provide problems and inspire students to be able to start investigating/investigating 	<ul style="list-style-type: none"> Students investigate / investigate problems that have been given. 	
Research	<ul style="list-style-type: none"> Lecturers provide and select material for students in order to gather sources of relevant information about the material. The lecturer guides discussions and sees if students develop an understanding of relevant concepts based on the project. 	<ul style="list-style-type: none"> Students collect relevant information from various sources. 	<ul style="list-style-type: none"> Abstraction Think creatively
<i>Phase 2 of Acquisition of Information</i>			
Discovery	<ul style="list-style-type: none"> Lecturers bridge research and general known information in project preparation. The lecturer divides students into small groups to present solutions to the problems given. 	<ul style="list-style-type: none"> Students develop project assignments based on the information that has been given. Students form groups according to instructions to present solutions to the problems given. 	<ul style="list-style-type: none"> Abstraction Think creatively
Application	<ul style="list-style-type: none"> The lecturer checks the results of problem-solving that the student has made from the previous provisions 	<ul style="list-style-type: none"> Students receive input from lecturers and use them to improve their assignments for the better 	
<i>Phase 3 Synthesizing of Knowledge</i>			
Communication	<ul style="list-style-type: none"> The lecturer sees the results of student projects utilizing students communicating the results of their projects in the classroom 	<ul style="list-style-type: none"> Students present the results of their projects in class 	<ul style="list-style-type: none"> Representation Mathematical proof

2-5- Motivation to learn

Motivation to learn is the overall driving force within students that causes learning activities, which ensures the continuity of learning activities and provides direction for learning activities to achieve the goals desired by the learning subject [76, 77]. Motivation is a power or strength that arises from within students to provide readiness to achieve predetermined goals. Meanwhile, learning is a process carried out by students to obtain better and previous behavior changes as a result of students' experiences in interacting with their environment. Student motivation includes dimensions [78].

Table 3. Dimensions of Student Motivation

Dimensions	Indicator
1. Persistence in learning	a) Attendance at school
	b) Participate in classroom learning activities
	c) Study at home
2. Resilient in the face of adversity	a) Attitude to adversity
	b) Attempts to overcome difficulties
3. Interest and sharpness of attention in learning	a) Habits in following lessons
	b) The enthusiasm in participating in learning activities
4. Excellent in learning	a) The desire to excel
	b) Qualification of results
5. Independent in learning	a) Completion of tasks
	b) Use opportunities outside of class hours

3- Research Methodology

This study used a quasi-experimental design. This type of research examines the effect of the hybrid learning model and learning motivation on AMT. A general schematic of the research method is shown in Figure 1.



Figure 1. Research of the methodology.

The design of this study was a non-equivalent control group design. This study did not use a random assignment but used an experimental class and a control class defined. The hybrid learning model was given to the experimental group, while the control group used conventional learning. An instrumented test is used to measure the students' initial abilities. The research design used in this study is as follows:

Table 4. Dimensions and Indicators of learning motivation.

Moderator Variables	Learning model	
	Hybrid Learning	Conventional (2)
Motivation to learn	X1Y1	X2Y1
High Learning Motivation (1)	X1Y1	X2Y1
Low Learning Motivation (2)	X1Y2	X2Y2

- X1 Y1: students who have high learning motivation in a class using a hybrid learning model (Experiment Class);
- X2 Y1: students who have high learning motivation in class using conventional models (Control Class);
- X1Y2: students who have low learning motivation in a class using a conventional hybrid model (Experiment Class);
- X2 Y2: students who have low learning motivation in the classroom use the conventional model (Control Class).

The subjects of this study were students of a mathematics education study program at a university in Bandung who attended lectures for the multi-variable calculus course. The sampling technique used was purposive sampling. Many variable calculus classes consisting of 2 classes were chosen as the experiment group and the other class as the control group. The sample consists of 40 people for each group. The experimental group was given treatment using hybrid learning, while the control group did not get treatment, namely only using conventional learning. Before implementing treatment, students of each class are given a pretest to see the fundamental abilities that students have before the treatment takes place.

Data analysis in this study used descriptive statistical analysis and MANOVA based on a factorial design. This technique helps analyze the dependent variable with interval and ratio scales. In this study, the dependent variable is AMT. MANOVA analysis technique with a significance level of $\alpha = 0.05$. The decision criterion is if the sign value > 0.05 , then H_0 is accepted, and if the sign value < 0.05 , then H_0 is rejected. Before conducting the MANOVA test, the researcher carried out requirements test to detect whether the data obtained met the requirements for analysis using an analysis technique that was planned following the research objectives. The basic assumptions that must be met before data analysis using the MANOVA analysis technique are (1) the data distribution is normal, and (2) the data is homogeneous.

Table 5. Dimensions and Indicators of learning Motivation.

Descriptive Statistics					
	Method	Motivation	Mean	Std. Deviation	N
AMT	Conventional Control	Low	58.50	12.34	16
		High	73.12	13.99	24
		Total	65.81	13.16	40
	Hybrid Learning Experiments	Low	65.11	12.47	15
		High	85.40	12.14	25
		Total	75.25	12.30	40
	Total	Low	61.81	12.41	31.00
		High	79.26	13.07	49.00
		Total	70.53	12.74	80.00

The results of the AMT description based on the learning model factor obtained an average AMT value in the hybrid learning class of 75.25 and the conventional class of 65.81. The results of the AMT description based on the interaction of learning model factors and motivational factors obtained an average AMT value in the hybrid learning class with the high motivation of 85.40 and with the low motivation of 65.11. Then the average AMT value in the conventional class with high motivation is 73.12 and 58.50 with low motivation.

3-1- Test Prerequisite Analysis

The following shows the results of the assumption test as a requirement for the MANOVA test, namely the normality test and the homogeneity test of variance. The normality test was performed using the Shapiro-Wilk test method, and

the variance homogeneity test was carried out by the Levene test method. The normality test was performed using the Shapiro-Wilk test method, and the variance homogeneity test was carried out by the Levene test method.

Table 6. Normality Test Results Based on the learning model factors.

Method		Tests of Normality					
		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistics	df	Sig.	Statistics	df	Sig.
AMT	Conventional Control	0.919	40	0.345	0.898	40	0.327
	Hybrid Learning Control	0.921	40	0.223	0.940	40	0.472

The results of the normality assumption test for the AMT variable based on the learning model factor obtained a significance value greater than 0.05 ($p > 0.05$) so that it was normally distributed.

Table 7. Normality Test Results based on Motivation factors.

Motivation	Kolmogorov-Smirnov				Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.	
AMT	High	0.704	31	0.234	.981	31	0.801
	Low	0.722	49	0.322	.977	49	0.474

The results of the normality assumption test on the AMT variable based on the learning model factor obtained a significance value greater than 0.05 ($p > 0.05$) so that it was normally distributed.

Table 8. Result of Variety Homogeneity Test.

	F	df1	df2	Sig.
AMT	2.242	3	80	0.629

The results of the homogeneity assumption test for the AMT variable based on the learning model factor obtained a significance value greater than 0.05 ($p > 0.05$) so that the results of the variance between groups were homogeneous.

3-2-Hypothesis Test Results

The following shows the MANOVA results for the AMT variable based on the learning model factors (hybrid learning model and conventional models) and motivation factors (high motivation and low motivation).

Table 9. MANOVA Test Results against AMT.

Factor		M	SD	F	Sig.	Remark
Learning model	Hybrid Learning	75.25	12.30	12.343	0.000	Significant
	Conventional	65.81	13.16			
Motivation	High	79.26	13.07	14.533	0.000	Significant
	Low	61.81	12.41			
Interaction	High Motivation Hybrid Learning	85.40	12.14	17.723	0.000	Significant
	Low Motivation Hybrid Learning	65.11	12.47			
	Conventional High Motivation	73.12	13.99			
	Conventional Low Motivation	58.50	12.34			

The first hypothesis is that the MANOVA test results based on the learning model factor of AMT obtained an F value of 12.343 with a significance of 0.000. These results indicate a significant difference of ($p < 0.05$) between the hybrid learning and the conventional groups towards AMT.

The second hypothesis is that the MANOVA test results based on the motivation factor for AMT obtained an F test value of 14.533 and a significance of 0,000. These results indicate a significant difference ($p < 0.05$) between AMT's high motivation and low motivation groups.

The third hypothesis is that the MANOVA test results based on the interaction of learning model factors and motivation factors on AMT obtained an F test value of 17.723 and a significance of 0.000. These results indicate a significant difference ($p < 0.05$) based on the interaction of learning model factors and motivation factors on AMT.

4- Discussion

From the results of this study, it was found that there was a significant difference between the hybrid learning group and the conventional group on AMT. It shows that many learning models and approaches can improve student learning outcomes, but not all learning models and approaches can design learning so that knowledge is constructed through student mental activities, providing more excellent opportunities for students to increase creativity, fun, challenge, and IT-integrated or technology-based. Learning that improves students' Advanced mathematical thinking and implementing an E-learning system is learning a hybrid learning model. The hybrid learning model is a learning model that combines various models, approaches, and learning media with the E-learning system (Science, Technology, Engineering, and Mathematics) and using Edmodo App in learning. This hybrid learning model aims to provide opportunities for prospective teachers to increase creativity and representational skills in concept mastery by utilizing the Project-Based Learning model and the STEM approach used by Rush and combined with the use of Edmodo application in teaching prospective teachers. Edmodo app is a social media application that has more functions to help lecturers manage a system that provides features to connect students and manage student activities easily. The researcher uses a syntax consisting of three stages in the hybrid learning model: seeking information, acquiring information, and synthesizing knowledge. These stages have been modified and adjusted to the needs of prospective teachers who will get treatment.

The hybrid learning model is one of the innovative lessons. It can construct and develop advanced mathematical thinking because hybrid learning provides opportunities for prospective teacher students to represent and abstract the mathematical concepts they understand in learning and provide opportunities to prove concepts that are they have understood and helped them to add and improve if there were errors during the process. Therefore, this research was conducted to improve the advanced mathematical thinking of prospective teacher students with a hybrid learning model. The quality of learning is based on Hybrid Learning; in this learning, students interact, discuss, exchange opinions or ideas about specific problems that can train their mathematical communication skills. Mathematical communication skills consist of oral communication and written communication. Oral communication such as discussion and explaining. While writ-ten communication, for example, expresses mathematical ideas through pictures, graphs, equations, tables, or in the students' language. If students have mathematical communication skills, then these students have Advanced Mathematical Thinking skills. Advanced Mathematical Thinking is the ability to think mathematically related to the thinking process of mathematicians, which focuses more on formal definitions, logical deduction, and creative thinking. Ervynck (2002) asserts that creative thinking has an essential role in the Advanced Mathematical Thinking process [79]. Creative thinking has an essential contribution in the process of deduction/proof. In the process of deduction, creative ideas are needed based on experience in the context of mathematics.

In addition, in this study, the results showed a significant difference between the high motivation group and the low motivation group on AMT. In the discussion of learning motivation, there needs to be an internal desire from a person. That can be seen from characteristics such as being diligent in facing tasks and resilient in facing difficulties. Then showing interest in various problems that occur, showing interest in various problems, preferring to work independently, quickly gets bored of ordinary things, can defend his opinion, does not easily let go of what is believed. Based on the division of the crucial elements above, the researcher will determine the relationship between the AMT indicator and learning motivation connected with hybrid learning in calculus material. Several studies showed a relationship between elements in the hybrid learning model and learning motivation towards AMT. Previous studies have shown that the average achievement and increase in students' cognitive abilities who receive ICT-assisted learning is higher than in conventional classrooms; the ability to understand students' statistics increased after students were given training on using SPSS software on statistical data processing. The same results are also shown by research.

The research above shows a significant difference between the learning model and motivational factors on AMT ability. The role of motivation in learning is significant because, with motivation, the learning presented by educators can be understood by learners because of the encouragement in them to be able to understand the information received. If there is no motivation in the learners, no matter how good the material presented, they will not be easily understood. The hybrid learning model can make it easier for teachers to understand their duties and responsibilities as an educator. This application contains interactive material so that it can bridge the teacher's learning motivation. According to Maya (2020), one strategy in increasing learning motivation is appropriate for learning motivation as a foundation tailored to learners' interests and needs [80]. Based on the results of this study, it was found that applying a learning motivation strategy in learning technology can increase the enthusiasm for learning in students because this learning motivation focuses on the attention, relevance, comfort, and satisfaction of each learner. More information received by the teacher will increase the teacher's understanding of their obligations, which also impacts improving teacher professionalism [53].

5- Conclusion

Based on the results of research carried out on students of the Mathematics Education study program at one of the universities in the city of Bandung. It was found that there was a significant difference ($p < 0.05$) between the hybrid learning group and the conventional group on the Advanced Mathematical Thinking ability, where the group given the hybrid learning treatment got a higher yield than the untreated group. The hybrid learning model is one of the innovative learning models. Hybrid learning models can build and develop advanced mathematical thinking because hybrid learning provides opportunities for prospective student teachers to represent and abstract mathematical concepts understood in learning and afford opportunities to prove theories they have understood and help them add and correct failures in the process. In addition, the group with high motivation and the group with low motivation have a significant difference of 0.000 with an F test value of 14.533. Thus, and based on the tests conducted, there are significant differences between the learning model factors and motivational factors on Advanced Mathematical Thinking. The role of motivation in learning is significant because, with motivation, the learning presented by educators can be understood by learners because of the encouragement in them to be able to understand the information received. If there is no motivation in the learners, no matter how good the material presented, they will not be easily understood. The hybrid learning model can make it easier for teachers to understand their duties and responsibilities as an educator.

6- Declarations

6-1- Author Contributions

Conceptualization, A.A.; methodology, D.; validation, A.A., D.J.; formal analysis, K.; investigation, D.; resources, K.; data curation, D.; writing—original draft preparation, A.A.; writing—review and editing, D.J. All authors have read and agreed to the published version of the manuscript.

6-2- Data Availability Statement

The data presented in this study are available in insert article.

6-3- Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

6-4- Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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