Journal of Research and Advances in Mathematics Education

Volume 7, Issue 3, July 2022, pp. 178-196
DOI: 10.23917/jramathedu.v7i3.18141
p-ISSN: 2503-3697, e-ISSN: 2541-2590

GeoGebra-based flipped learning model: An alternative panacea to improve students' learning independency in online mathematics learning

Naufal Ishartono[1]*, Adi Nurcahyo[1], Mohamad Waluyo[1], Rafiza Abdul Razak[2], Suliadi Firdaus Sufahani[3], Millenia Hanifah[1]

[1] *Department of Mathematics Education, Universitas Muhammadiyah Surakarta, Indonesia*
[2] *Department of Curriculum and Instructional Technology, University of Malaya, Malaysia*
[3] *Department of Mathematics, Universiti Tun Hussein Onn Malaysia, Malaysia*

Citation: Ishartono, N., Nurcahyo, A., Waluyo, M., Razak, R., Sufahani, S., & Hanifah, M. (2022). GeoGebra-based flipped learning model: An alternative panacea to improve student's learning independency in online mathematics learning. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, 7(3), 178-196. https://doi.org/10.23917/jramathedu.v7i3.18141

ARTICLE HISTORY:
Received 22 April 2022
Revised 6 July 2022
Accepted 23 July 2022
Published 31 July 2022

KEYWORDS:
GeoGebra
Flipped Learning
Learning Independency

ABSTRACT

Previous studies have tried to improve students' independence in online mathematics learning. However, the Flipped Learning model integrated with GeoGebra is scarce as none of the existing syntaxes accommodate the model. As the existing syntax is based on three phases: pre-class activity, in-class activity, and post-class activity. This research aims to develop GeoGebra-based Flipped Learning syntax to increase students' independence in learning mathematics. The main difference between the existing syntax and the developed one is the integration of GeoGebra in the pre-class activity. The integration is based on previous studies showing that using GeoGebra can improve student's learning achievements. It research employed the Design-Based Research (DBR) model involving 125 second-year undergraduate students of a private university in Indonesia. The syntax results were obtained from the study, indicating an increase in the average value of student independence in learning mathematics based on learning independence, confidence, level of discipline, sense of responsibility, level of initiative, and self-control. This developed syntax is expected to help teachers streamline online mathematics learning.

INTRODUCTION

The Covid-19 pandemic has significantly affected various sectors, such as the economic, defense, social, cultural, and education sector (Chick, 2020; K et al., 2020; Magomedov et al., 2020; Somthane et al., 2020; Wan Ahmad et al., 2019). The education sector is drastically affected by the sectors (Worldometer, 2020). Many countries have to adapt to the impact of the pandemic, not to mention Indonesia (Purwanto et al., 2020). In order to respond to the outbreak of Covid-19, the Indonesian Ministry of Education and Culture issued an emergency policy that recommends that learning be shifted from face-to-face to online mode (MoE, 2020). The policy has been taken seriously by various educational institutions in Indonesia. At the college level, research has been done to investigate how the learning process can run effectively and efficiently during online learning (Purwanto et al., 2020). Previous studies have shown that the blended learning approach during the Covid-19 pandemic is the most appropriate approach (Rahiem, 2020; Slamet et al., 2021; Yustina et al., 2020).

Theoretically, blended learning is an approach that combines online educational materials and opportunities for interaction online with traditional place-based classroom methods (Banditvilai,

*Corresponding author: ni160@ums.ac.id

2016). Based on the definition, the blended learning approach is considered an alternative solution to streamlining learning by reducing physical encounters (Atmojo et al., 2020; Ilmi et al., 2020; Kusumaningrum et al., 2020). One of the blended learning approaches used during the pandemic is the flipped learning model (Latorre-Cosculluela et al., 2021; Nerantzi, 2020).

Flipped learning

Flipped learning is a model in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter (Bergmann & Sams, 2012). As shown by a systematic review article done by O'Flaherty et al. (2015), the application of Flipped Learning can improve students' learning experience by creating more dynamic interactions. In addition, the application of this model can also improve students' learning achievement (Rotellar & Cain, 2016; Sharma et al., 2015; Sutama et al., 2020). Briefly, the Flipped Learning model is done through three stages: before-class activity, in-class activity, and after-class activity (Flipped Learning Network (FLN), 2014) (see Figure 1. for the design). Previous studies that examined the application of Flipped Learning model found that the basis of Flipped Learning application is the use of learning videos in the before-class activity stage, where students are asked to see and summarize the information they get from the video (Davies, 2013; Hwang et al., 2015; Lin et al., 2019). Based on those previous studies, the authors consider that the students are not actively involved in concept construction. However, the active involvement of students in constructing their knowledge can make the learning process more meaningful (Agra et al., 2019). Therefore, what needs to be improved from the Flipped Learning model is how to involve students' activeness by improving their learning independence.

Independent learning

Independent learning is a condition where students are responsible for their learning because all learning can, in any case, only be carried out by the students themselves and because they need to develop the ability to continue learning after their formal education ends (Littlewood, 1999; Tanti et al., 2020). Hubbard states that good independent learners will finish all their homework, actively participate in classroom activities, regularly seek advice from teachers, and frequently visit Self-Access Centers or libraries (Hubbard, 1994). The aforementioned definitions can shed light on the term independent learning. A person with high learning independence tends to be confident in managing his learning (Firdausy et al., 2019; Sakai et al., 2010; Usuki, 2000). Little states that independent learning is not an attempt to alienate students from their learning environment or self-study, but independent learning is "an ability to take charge of one's learning" (Little, 1996). In addition, Little (1996) also states that independent learners can possess the ability to make decisions concerning all aspects of learning, namely (1) determining the objectives, (2) defining the contents and progressions, (3) selecting techniques and methods to be used, (4) monitoring the used procedures, and (5) evaluating what has been acquired. From the five parameters, it can be seen that a lack of learning independence will be an obstacle for students to acquire knowledge, mainly if the subject studied have abstract objects such as mathematics.

Why GeoGebra?

Mathematics taught at the university level has a very high level of abstraction, such as plane geometry analytics, advanced calculus, statistics, abstract algebra, real analysis, numerical method, and many more (Sierpinska et al., 2008). The topics are challenging enough to be studied online, especially if they are learned using the Flipped Learning model that does not actively involve students in independently acquiring their knowledge. Then, the learning process will be more challenging. Considering the importance of mathematical mastery and the Covid-19 pandemic that forces learning to be implemented in a blended mode, a media that can be integrated into the Flipped Learning model is needed to increase students' independence in learning mathematics. One of the media that can be integrated is GeoGebra.

GeoGebra is a dynamic software that combines the concepts of geometry, algebra, and calculus in its optimization and can help visualize abstract mathematical objects (Fatahillah et al., 2020; Ishartono et al., 2016; Judith & Markus, 2008). Furthermore, this software is user-friendly. So, it does

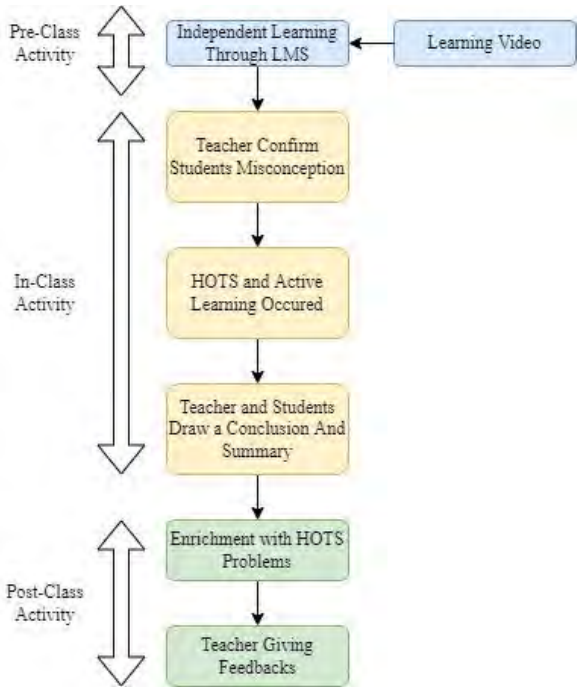

Figure 1. Syntax of flipped learning

not require particular computer expertise (Hohenwarter et al., 2009; Klemer & Rapoport, 2020). Previous studies show that implementing GeoGebra can increase students' analytical ability and activeness in learning mathematics (Hermuttaqien et al., 2019; Kholid et al., 2022; Kllogjeri, 2010; Kristanto et al., 2016a; Septian et al., 2019; Yamin et al., 2020).

GeoGebra-based flipped Learning

As previously explained, online mathematics learning—one of the impacts of the Covid-19 pandemic—is challenging for students due to limited interaction with teachers and access to existing mathematics props. Therefore, students' independence in learning mathematics online is one of the crucial things that must be improved. The learning independence in question is with all the limitations that exist, students can construct their knowledge independently based on learning resources/media provided by the teacher. In the flipped learning model scheme, one of the crucial phases that are the basis for implementing this model is the pre-class activity phase. As previously explained, this phase gives students the flexibility to prepare themselves before in-class activities. The form of preparing is to independently construct their understanding through the learning media that the teacher has given. Therefore, this phase can be optimized by integrating with mathematics learning media that can increase student activity in using their analytical abilities to construct their mathematical experience independently. In these conditions, the GeoGebra application acts as an escalator of the independence of students constructing their mathematical understanding independently.

Some of the characteristics of GeoGebra that are suitable to be integrated in the flipped learning model in the implementation of online mathematics learning are the interfaces that make it easier for students to manipulate objects displayed in the GeoGebra-based learning media. Features such as lines, points, fields, and other mathematical objects can help students manipulate the displayed mathematical objects. In addition, the completeness of tools in GeoGebra also makes it easier for teachers to design visualizations of the mathematical topics being taught. Next, another feature that GeoGebra has is that this application is also available as a website. Therefore, the level of accessibility of this device is high, making it easier for students to be accessed anywhere. The exciting thing about the GeoGebra website is that this website can also act as a learning management system (LMS) where all GeoGebra-based learning media can be arranged in a series of learning activities.

The strengthening of the role of GeoGebra in the syntax of flipped learning is not only as a learning medium, but as an investigative median of a concept. Therefore, the integration of GeoGebra in this study does not stand alone, but is complemented by investigative questions. In principle, investigative questions serve as a complement to GeoGebra where it is through these questions that students will carry out various investigations that lead to a concept. This is in accordance with the framework of mathematical tasks carried out by Smith & Stein (1998) pada framework high-level demands (doing mathematics). The framework consists of six points, namely (1) require complex and nonalgorithmic thinking, (2) require students to explore and understand the nature of mathematical concepts, (3) demand self-monitoring, (4) require students to access relevant knowledge and experiences and make appropriate use of them in working though the task, (5) require student to analyze the task and actively examine task constraints that may limit possible solution strategies and solutions, and (6) require considerable cognitive effort and may involve some level of anxiety for the student because of the unpredictable nature of the solution process required.

Significance of the study

Few previous studies examined the effort to strengthen students' learning independence in studying mathematics at the university level during the pandemic. Houston and Lazenbatt used peer-tutoring to increase students' independence in learning mathematics. However, this study was conducted long before the pandemic (Houston & Lazenbatt, 1996). Besides, a study by Saputra and Fahrizal (2019) shows that using GeoGebra improves university students' learning independence in studying mathematics. However, this study was not conducted in an online learning condition.

Previous studies have investigated the integration of Flipped Learning model and GeoGebra, such as; (1) Nuraeni et al. (2021), who developed a learning tool on the flipped learning model assisted by GeoGebra to improve the mathematical representative skills of secondary school students in Indonesia, (2) Ishartono et al. (2022) who studied the integration of GeoGebra into Flipped Learning model to improve students' self-regulated learning, and (3) Andriani et al. (2022) who integrated Flipped Learning and GeoGebra to improve students' critical thinking skills during online learning. However, there is a lacuna in studies which examine how the integration of GeoGebra and Flipped Learning increases students' independence in learning mathematics during the Covid-19 pandemic.

In the context of online mathematics learning, the independence of learning mathematics becomes essential for students to have because all the limitations of place and time require them to actively construct their own understanding of mathematical concepts based on learning resources provided by teachers (Liaw et al., 2007), especially during the Covid-19 Pandemic which requires them to remotely study the materials instead of being surrounded by their teachers/tutors. The present study is critical because the results will reveal the steps to increase students' independence in learning mathematics online. This will benefit practitioners, researchers, and stakeholders in mathematics education, especially in improving the quality of online mathematics learning.

Research objective

Based on the aforementioned description, the researchers consider it necessary to develop a learning syntax that integrates GeoGebra into Flipped Learning to increase students' independence in learning mathematics during the Covid-19 pandemic. However, until now, no syntax can accommodate such efforts. So, the question is what syntax can accommodate the improvement of students' learning independency in studying mathematics online. This study aims to fill the theoretical gaps by developing the syntax of the GeoGebra-based Flipped Learning model to increase students' independence in learning mathematics during the Covid-19 pandemic.

METHODS

This Research & Development (R&D) research employed the Design-Based Research (DBR) model. Armstrong et al. (1992) Design-Based Research is one of the research models that applies iterative design to develop knowledge that improves educational practice, such as developing a learning syntax. The model comprises the following stages: the analysis and exploration phase, the design and construction phase, the implementation, and the evaluation and reflection (see Figure 2) (Reeves, 2006).

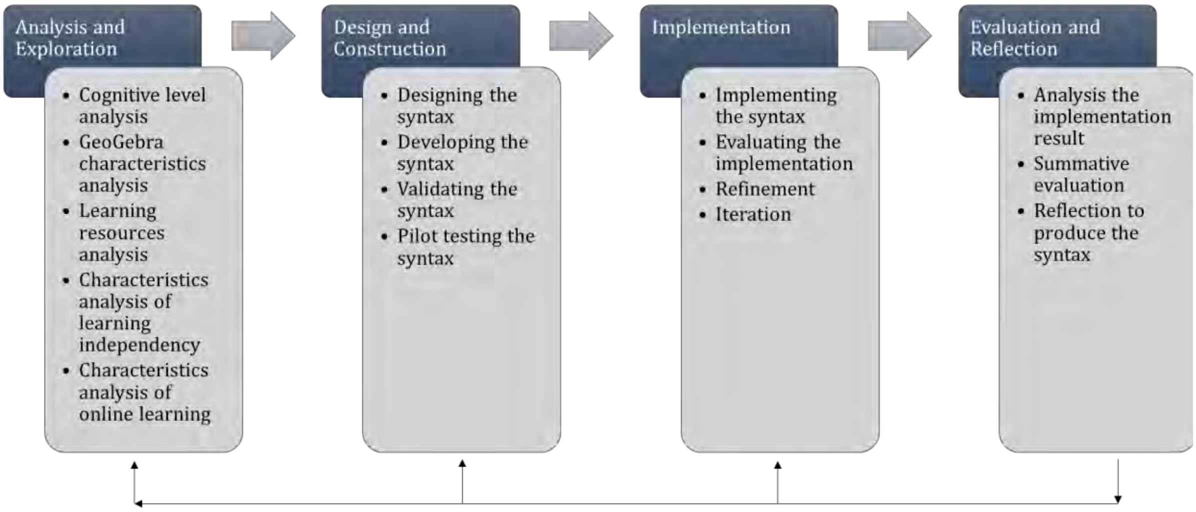

Figure 2. Design-Based Research phases

Analysis and exploration phase

This first phase is critical in the entire development process because the outcome of this phase becomes the foundation for the next phase. Therefore, in this stage, several analyses such as cognitive analysis of students based on Bloom's Taxonomy, analysis of the existing learning resources related to GeoGebra, analysis of the best mathematical learning strategies to use online, learning independency aspect, as well as appropriate learning media for students based on aspects of GeoGebra and online learning.

Design and construction phase

This phase is based on the analysis and exploration phase where the information obtained is developed into components of the intended syntax. Furthermore, each component is tested for validity by two experts. Validation results are analyzed quantitatively (validation sheet data) and qualitatively (suggestions and input validators). Quantitatively, the results of the validation sheet are then analyzed using Cohen's Kappa inter-rater formula to test the reliability of the two designated validators, as well as Aiken's Coefficient Value formula to test the content validity index (CVI) (Ishartono et al., 2022; McHugh, 2012). Qualitatively, the inputs obtained from validators become evaluation materials to be revised periodically. In this stage, there is an iteration process where the components are consulted again to the validator to assess the revision results after the revision process is completed.

Once the component is completed, it is constructed to be the initial design of the GeoGebra-Based Flipped Learning syntax. Next, the syntax is validated in theory by two experts, where the validation results are analyzed just like the component validation process that has been done before. The iteration process also occurs in the construction stage, where after the revision process is carried out, the design is then consulted again by the validator.

Implementation of the syntax

Furthermore, in theory, design validation is then implemented in the learning process. In this research, the implementation was carried out at one of the private universities in Central Java, Indonesia, and involved 125 second-year undergraduate students. The students consisted of 98 female and 27 male students who have been learning mathematics for two years. The university selection is based on the availability of facilities that support the mixed learning process, such as the internet's capacity, sufficient computers, and the completeness of the mathematics laboratory.

This implementation was carried out in two meetings on the plane geometry analytic course, which aimed to see the obstacles during the syntax design implementation. In addition, it was used to see how significant the design has been developed in increasing student independence in learning mathematics during online learning. Two instruments are used to obtain the data: observation sheets

Table 1
Items of Independent Learning Instruments

No	Scoring Aspects	Item No.
1	Independence of others	1(-), 4(-), 6(+), 16(+)
2	Self-confidence	8(+), 10 (-), 17(+)
3	Discipline	11(+), 12(-), 18(+)
4	Sense of responsibility	7(+), 13(-), 14(+)
5	Initiative	2(+), 3(+), 5(-), 20(+)
6	Self-control	9(+), 15(-), 19(+)

to see and record obstacles during the implementation process and questionnaires to assess students' learning independence based on the criteria developed by Little (1996). The observation process is carried out in each meeting as an iteration of the evaluation process, while the questionnaire is only given at the end of the meeting. The questionnaire uses a Likert scale from 1 (strongly disagree) to 4 (strongly agree), combining negative and positive question types. The questionnaire items of learning independence are adapted from the instruments developed by Hidayati and Listyani (2013). Items of the instruments can be seen in Table 1.

Evaluation and reflection phase

This stage is done by evaluating the results obtained in the second stage, which are the results of observations related to implementation constraints and questionnaire results that have been distributed to students. The observation results are analyzed qualitatively, while the questionnaire results are analyzed quantitatively. The iteration process is also carried out in this stage based on the results of observations that have been obtained. If an obstacle is found in the developed syntax aspect, it is fixed and piloted again. After obtaining the results of the quantitative and qualitative analysis, reflection on whether the application of GeoGebra-based Flipped Learning can significantly increase students' independence while studying mathematics online is done. This stage is based on Normalized Gain (N-Gain) Test to see the effectiveness in improving students' learning independency during online mathematics learning (Bao, 2006). The results are categorized using the category table from Meltzer (2002).

FINDINGS

Analysis and exploration phase

In this stage, the authors conduct a literature review on the syntax aspect of Flipped Learning model, aspects of learning independence characteristics, aspects of mathematical topics that will be used as the basis for GeoGebra media development, and aspects of GeoGebra itself. The first aspect analyzed is the syntax aspect of Flipped Learning model. This model is implemented through three stages, namely (1) the pre-class (asynchronous) stage, where teachers provide learning materials for students to learn, (2) the in-class (synchronous) stage, where teachers deepen students' understanding through exercises to work on questions or implementation of learning models based on Higher Order Thinking Skills (HOTS), and (3) post-class (asynchronous) stage where teachers evaluate the learning outcomes of students in the form of feedback or additional projects (Murillo-Zamorano et al., 2019).

The next aspect analyzed is the characteristics of students' learning independence. According to Hidayati and Listyani (2013), there are six indicators which reflect students' independence in learning, i.e. (1) being independent, (2) having confidence, (3) behaving discipline, (4) having a sense of responsibility, (5) behaving on their initiative, and (6) conducting self-control. These six factors are the basis for developing questionnaires used to see the level of students' independence in learning mathematics.

The third aspect studied is the topic used to develop GeoGebra-based teaching media. In this study, the developed syntax is implemented in mathematics subjects at the university level. Therefore, the chosen topic was the topic of circles contained in the course of plane geometry analytic. The selection of this topic is based on its suitability with GeoGebra applications that accommodate geometry and the record of assessment results in the previous academic year at the private university where students' scores are relatively low in this course in 2020 compared to those in the previous years.

The last aspect analyzed is the GeoGebra software; this study used GeoGebra 5.0. This software can be easily used to illustrate abstract mathematical objects such as geometric objects. In addition to the offline version of GeoGebra, the researchers also use the GeoGebra applet version, which can be accessed at the following link https://www.geogebra.org/m/p7yypye4. Initially, GeoGebra-based learning media was designed using GeoGebra 5.0. Next, a validity test was conducted on the media. The last is uploading the files into the applet so the students can operate and manipulate it online (Nisiyatussani et al., 2018). Of course, the GeoGebra-based learning media does not stand alone, but it includes investigative questions that lead students to a concept that must be mastered. These questions' function as scaffolding questions so students can construct their knowledge independently. This condition is based on the results of research from Kristanto et al. (2016b), which combined investigative questions in computer software-based learning media to direct students to understand a concept.

Design and construction phase

Designing the development components

The authors began this stage by designing the GeoGebra-based Flipped Learning syntax component to increase students' independence in learning mathematics, assessment instrument designs to assess the GeoGebra-based learning media, and questionnaires to assess the level of independence of college students in learning mathematics. The first design was the syntax of the GeoGebra-based Flipped Learning model to increase the independence of college students in learning mathematics. The syntax was designed based on Little's five learning independence aspects in the previous explanation (Little, 1996). In addition, two aspects distinguish this syntax design from the existing syntax. It does not use video as the basis for delivering materials in the pre-class activity stage but uses GeoGebra, which is equipped with investigative questions. Also, in-class activity is implemented offline in the existing syntax. Then, the phase is implemented online (synchronous) in this syntax design. Afterward, the researchers detail the GeoGebra-based mathematical learning media design that can increase students' independence in learning mathematics, focusing on circles. Indeed, as presented at the analysis stage, the media is equipped with investigative questions that lead students to the concept circle.

The author designed a questionnaire to assess students' independence in learning mathematics to see the level of student independence. It was a modification of the questionnaire developed by Hidayati & Listyani (2013). The questionnaire used a four-figure even Likert scale of 1 for "strongly disagree", 2 for "disagree", 3 for "agree", and 4 for "strongly agree" (Suharsimi, 2006). Furthermore, the questionnaire results will be analyzed quantitatively using SPSS 23 to see an increase in the average level of student independence in learning mathematics. The questionnaire was distributed using Google Form to collect data.

Syntax development

This stage was done by developing syntax that was based on the previously designed components.Furthermore, the development results were conducted internal validation by involving two expertsin the field of educational technology from one of the private universities in Indonesia. The validation process was carried out using a walk-through interview model, where the components that had been prepared were then commented on directly by the two experts and given input on improvements. The validation aspects include (1) the conformity of the syntax with the model used, (2) the suitability of the learning media (GeoGebra) used in the syntax, and (3) the conformity of the syntax to the learning sequence in the classroom (Indartono, 2019). Input from both experts is used to improve the developed syntax, and the results can be seen in Table 2.

Table 2
The initial design of geogebra-based flipped learning to teach mathematics for college students

Phases	Teacher Activity	Student Activity	Note
Pre-Class Activity	Setting a Learning Management System (LMS)	Creating an account to login into the LMS	The LMS is used to help teachers organize the online class easily.
	Distributing Applet GeoGebra link to students via LMS	Answer questions contained in the Applet GeoGebra equipped with investigative questions **Learning Independence Aspects:** 1. Determining the objectives 2. Defining the content and progression 3. Selecting techniques and methods to be used	At this stage, the students independently construct their knowledge through the investigative questions contained within the Applet GeoGebra
	Checking students' answers on Applet GeoGebra as discussion material for the In-Class phase	Listing questions to ask related to the material studied in the applet **Learning Independence Aspects:** 4. Monitoring the used procedures	Students' answers can be used as material for teachers to ascertain which material points are being taught, which are not yet understood by students.
In-Class Activity	Conducting a question-and-answer session with students regarding the material that students have studied	Conducting Q&A with teachers regarding the material they have learned and related to the things they still confuse **Learning Independence Aspects:** 4. Monitoring the used procedures	Teachers use this question-and-answer process to ensure students' understanding of the material they have learned.
	Deepening students' understanding with Higher Order Thinking Skills (HOTS) based questions or by working on a project by using Project-Based Learning Integrated with GeoGebra	Working on HOTS-based questions or doing a project as what is directed by the lecturer	This process aims to deepen students' understanding of the material they have learned before through HOTS questions or a project using Project-Based Learning integrated with GeoGebra to make the learning process meaningful.
	Together with students, concluding what concepts have been learned and how to solve problems related to them	Together with lecturers, conclude what concepts have been studied and how to solve problems related to the concept	This process aims to summarize what concepts students have learned and how they use them to solve problems related to them.

Table 2 (Continue)

Phases	Teacher Activity	Student Activity	Note
Post-Class Activity	Evaluating students' understanding by providing enrichment HOTS questions or additional projects	Working on enrichment questions or additional projects provided by the lecturer **Learning Independence Aspects:** 5. Evaluating the knowledge that has been acquired	This process aims to ensure the understanding of students wholistically
	Assessing and providing feedback on student work	Understanding the value and feedback that lecturers have given	This process aims to strengthen students' understanding of the materials they have learned

GeoGebra-based Learning media with investigative questions (GLMIQ)

At this stage, the learning media is developed according to the design described in the design stage. The development of the media was based on the indicators from the topic of the circle that was being taught. Those are (1) compiling equations of circles and using them in problem-solving and (2) determining the equation of tangents of circles that meet specific criteria. In addition, the media is also developed using investigative questions that direct students to construct their knowledge independently. After the development process finished, it was validated by two experts in mathematics learning media from a private university in Indonesia. The experts validated the aspects of content and media. The results of the validation assessment conducted by the two experts were then used to assess the reliability level of inter-raters using Cohen's Kappa formula. The results of the test can be seen in Table 3. The table shows that the reliability level is 0.89, which means that the reliability level of both validators is highly rated. Then, the validity of the content was tested using Aiken's Coefficient Content Validity Index (CVI). The average CVI obtained for content aspects is 0.81, categorized as valid, and an average CVI for media aspects is 0.79, categorized as valid. Based on the result, the developed GeoGebra-based learning media can be used in the learning process. The GLMIQ can be accessed at the following link https://www.geogebra.org/m/xb7psqnw. The Conformity of GeoGebra-based flipped learning with the mathematical task framework proposed by Smith & Stein (1998) can be seen in Table 4.

Questionnaire Development

In this study, two types of questionnaires were developed pre-test and post-test. Both questionnaires are based on aspects of learning independence presented by Hidayati & Listyani (2013). What distinguishes the two questionnaires is that the pre-test questionnaire focuses more on their experience regarding aspects of their independence in constructing their knowledge, and the post-test questionnaire focuses on students' experience related to improving their learning independence during the study of mathematics based on the GeoGebra-based Flipped Learning (GbFL) model (see Table 5).

After completing the development, the questionnaires were then validated by two experts in learning evaluation from one of the private universities in Indonesia. The validity test results were then used to test the reliability levels of both validators using Cohen's Kappa inter-rater reliability test, where the results showed 0.811, which can be categorized as a strong level of reliability. After that, the validity results were used to do a validity test using the Content Validity Index Aiken's Coefficient Value obtained by each point of the two questionnaires developed has a good level of validity with the lowest score was 0.77.

Phase of syntax implementation

This stage was held online for two meetings: the sixth (April 16, 2021) and the seventh (April 23, 2021). In its application, the authors collaborated with the lecturer, who enables the course to carry out the learning process according to the syntax developed in each meeting. The implementation begins with a pre-class activity where teachers provide GeoGebra-based learning

Table 3

Inter-rater reliability test Cohen's Kappa

Category	Value	Asymptotic standardized error[a]	Approximate t[b]	Approximate significance
The Measure of Agreement (Kappa)	0.89	0.075	5.872	0.000
N of Valid Cases	43			

Table 4

The Conformity of GeoGebra-based flipped learning with the mathematical task framework proposed by Smith and Stein (1998)

No	Points of the Framework	Parts in the GLMIQ
1	Require complex and non-algorithmic thinking	All questions given in investigative questions are not algorithmic. It can be seen in the list of questions displayed in the GLMIQ.
2	Require students to explore and understand the nature of mathematical concepts	To answer each question given, students are required to manipulate GLMIQ
3	Demand self-monitoring	Self-monitoring is given in the form of questions that ask students to look back at the way they have done it, such as "Are you sure about your answer? Please re-check your answer by entering another value in the input in the mathematics learning media".
4	Require students to access relevant knowledge and experiences and make appropriate use of them in working though the task	In the process of answering questions and manipulating the GeoGebra-based learning media, students need to use their previous understanding. For example, as in the GLMIQ, students must understand the concept of a circle before manipulating the GeoGebra-based learning media.
5	Require student to analyze the task and actively examine task constraints that may limit possible solution strategies and solutions	Some of the investigative questions given in the GLMIQ are analytical in nature where students are asked to analyze the impact of a number manipulation in the GLMIQ. For example, there is a question says, "If A is a point on the circle, and B is the center point. What will happen to the circle if the distance between coordinates A and B increases?"

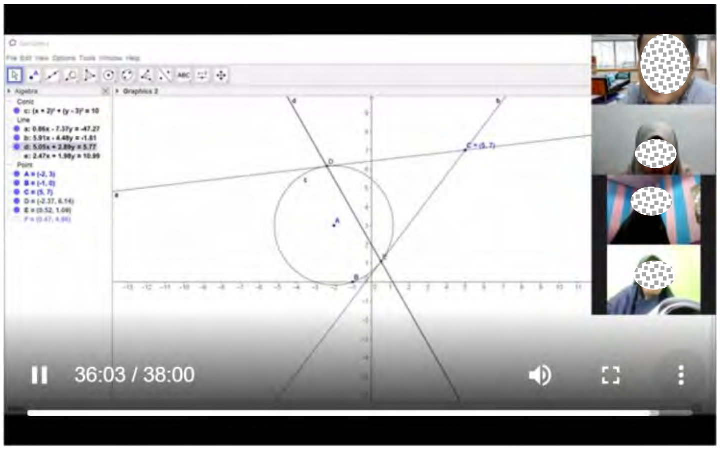

Figure 3. Sample of an activity in In-class activity

media on the topic circle to students through the LMS that has been set. Then at the in-class activity stage, the lecturer validates and deepens students' understanding of the topic of the circle. Figure 3 is the sample of an in-class activity in which the lecturer validated students' understanding of tangents drawn from points outside a circle. Finally, lecturers provide evaluation and enrichment to students in the post-class activity stage as an additional task to strengthen students' understanding.

Table 5
Points of the questionnaire

Aspects	Points in Pre-Test	Points in Post-Test
Being Independence	• Student self-reliance so far in determining the learning goals • Student self-reliance so far in constructing their knowledge • Student independence so far in analysing their learning difficulties • Student independence during this time in finding solutions to the difficulties they encountered during the knowledge construction process • Student independence during this time to understand the material taught	• Student independence during the implementation of the GbFL model in determining learning goals • Student self-reliance during the application of the GbFL model in constructing their knowledge • Student independence during the application of the GbFL model in analysing their learning difficulties • Student independence during the application of the GbFL model in finding solutions to the difficulties they encounter during the knowledge construction process • Student independence during the application of the GbFL model to understand the materials taught
Having confidence	• The confidence of students so far related to the learning strategies they have chosen • The confidence of students so far related to the achievement of their learning goals	• Student confidence during the implementation of the GbFL model related to the learning strategy they choose • Student confidence during the implementation of the GbFL model related to the achievement of their learning goals
Behaving discipline	• Student discipline during this time in making a learning plan • Student discipline during this time in making a problem-solving strategy • Student discipline during this time to always double-check their work	• Student discipline during the implementation of the GbFL model in making learning plans • Student discipline during the application of the GbFL model in making problem-solving strategies • Student discipline during the application of the GbFL model to always double-check their work
Having a sense of responsibility	• Students' understanding so far related to the consequences of the learning strategy they chose • The student's efforts so far to continually validate their understanding through various references	• Student understanding during the implementation of the GbFL model related to the consequences of the learning strategy they selected • The student's efforts during the implementation of the GbFL model to continually validate their understanding through various references
Behaving on their initiative	• Student initiatives so far to record all the obstacles they encounter to be asked to lecturers • Student initiatives during this time to find solutions from various references related to their obstacles during the study	• Student initiatives during the implementation of the GbFL model to record all the obstacles they encounter to be asked to lecturers • Student initiatives during the implementation of the GbFL model to find solutions to various references related to their constraints during the study

Table 5 (Continue)

Aspects	Points in Pre-Test	Points in Post-Test
Conducting self-control	• Students' efforts so far in evaluating their learning strategies • The efforts of students so far to always confirm their understanding to lecturers • The efforts of students so far to continuously improve the way they construct their understanding • The efforts of students during this time to continuously monitor their learning progress	• Student efforts during the application of the GbFL model in evaluating their learning strategies • Student efforts during the application of the GbFL model to always confirm their understanding to lecturers • Student efforts during the application of the GbFL model to continuously improve the way they construct their understanding • The efforts of students during the application of the GbFL model to continuously monitor their learning progress

Table 6
The analysis of the pre-test and the post-test result

Aspect	N	Pre-Test		Post-Test		*N-Gain*	Category
		Mean	Std. Deviation	Mean	Std. Deviation		
Being independence	125	1.9440	0.369481	2.8448	0.38843	0.438132	Medium
Having confidence	125	1.9360	0.595602	2.9560	0.54260	0.494186	Medium
Behaving discipline	125	2.1280	0.385173	3.1307	0.42733	0.53563	Medium
Having a sense of responsibility	125	1.9800	0.626691	2.8320	0.53861	0.421782	Medium
Behaving on their initiative	125	2.0480	0.655079	2.9800	0.59704	0.477459	Medium
Conducting self-control	125	2.0520	0.373378	2.8800	0.45636	0.425051	Medium

The authors first distributed a pre-test questionnaire to students on a pre-class activity in the sixth meeting to measure students' independence level in knowledge construction. Meanwhile, for the post-test questionnaire, the authors gave it to the post-class activity in the seventh meeting. Those questionnaires were distributed using Google Form to make them easier to analyze. All questionnaires were then analyzed as material at the evaluation stage.

Evaluation and reflection phase

This stage is based on twice the process of applying Gb-FL in the previous phase. Based on the observations that have been made, the obstacles found are technical problems, namely the lack of solid internet networks owned by students or computers that are less supportive of operating GeoGebra online. For the rest, there are no constraints related to the order of syntax that has been developed.

Next, collecting the results of the pre-test and post-test questionnaires that students have filled. The collected data were analyzed descriptively by using SPSS 23. The analysis results for the pre-test and the post-test questionnaires can be seen in Table 6. The table shows that the average student response score for each aspect of the pre-test is above 1.5, while in the post-test, it is above 2.5. Meanwhile, when viewed from the normalized gain test value, it is obtained that all aspects are categorized as a medium. According to Meltzer (2002), the medium category indicates that the syntax developed effectively increases students' learning independence in terms of each aspect assessed.

DISCUSSION

The big idea of this study is to increase students' independence in learning math during online learning. This becomes important to study because of two things: mathematics and online learning. As has been stated before, that mathematics has an abstract work object. On the other hand, after the

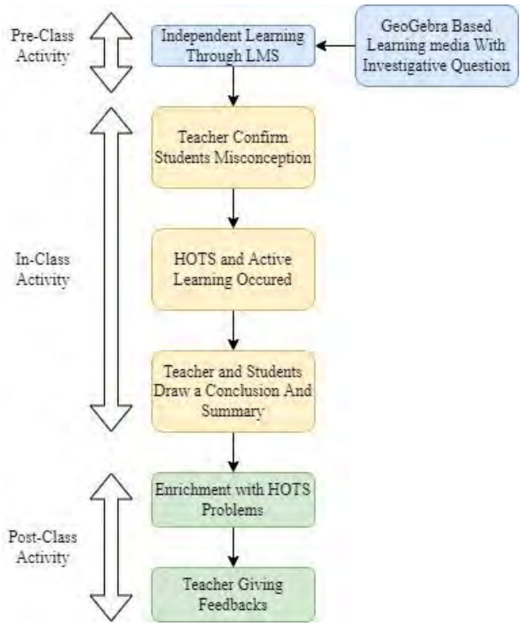

Figure 4. Design of GeoGebra-based flipped learning

emergence of the Covid-19 pandemic, the tendency to organize online learning has increasingly become a top priority for the effectiveness and efficiency of learning time. This is in line with the study of Subakri & Annizar (2021), who saw that the emergence of the Covid-19 pandemic directed various education practitioners to stakeholders to organize online learning. In the context of mathematics, it becomes a challenge to teach abstract mathematical concepts online due to the limitations of physical interaction between teachers and students. This requires students to equip themselves with various knowledge related to mathematical concepts more actively. Therefore, students' independence in learning mathematics online becomes essential.

In the present study, the syntax modification of the Flipped Learning model became an alternative effort to increase students' independence in learning mathematics online. The modification that emerged in the study was integrating the integrated GeoGebra investigative questions software—instead of video learning—which was placed at the pre-class activity stage. This replacement is carried out in the Design and Construction phase equipped with a content validity test based on Aiken's Value formula, which is reviewed from the media aspect, and the content aspect is categorized as valid (see Table 2). Once the media is completed, it is then integrated into the syntax of Flipped Learning model as a modification (see Figure 4. as a form of visualization).

In the Design and Construction phase, the modified syntax was implemented at one of the private universities in Indonesia. As previously stated, this implementation is carried out to obtain qualitative data from field observation results related to the constraints of the implementation of learning based on the modified syntax, and also quantitative data based on the results of spreading student learning independence questionnaires during online mathematics learning. The analysis results obtained in the Evaluation and Reflection phase are, qualitatively, there are no significant obstacles related to the syntax that is carried out in sequence. Table 4 shows that all aspects of learning independence are categorized as medium or quite effective. This means that the syntax developed effectively increases students' independence in learning mathematics online.

The present study used the Design-Based Research (DBR) model instead of any other development models such as ADDIE (Analysis, Design, Development, Implementation, and Evaluation) (Bichelmeyer, 2005), Dick and Carey (Corbeil et al., 2005), and Borg & Gall (Gall et al., 1996). The consideration is that DBR is a development model used to develop instructional models (Mckenney & Reeves, 2014), while other development models are models used to develop physical products such as learning media, books, etc. The most significant differentiator is that in DBR, there are no limited trial sub-phases; the replacement is iteration at the implementation stage. While in other development models, there are limited sub-phase trials to see if the developed product has technical faults, such as the readability and practicality the developed product. Some previous studies used DBR to develop learning models (Koivisto et al., 2018; Ustun & Tracey, 2020), learning environments (Wang & Hannafin, 2005), and mobile learning frameworks (Bikanga Ada, 2018). Therefore, DBR is considered appropriate in answering the purpose of this research.

In addition to syntax development, this research also focuses on developing students' learning independence during online mathematics learning. The results of the quantitative analysis in Table 4 show that the syntax developed effectively improves students' learning independence. This might be contributed to the role of GeoGebra-based Learning Media with Investigative Questions (GLMIQ) embedded in the pre-class activity phase, providing facilities for students to study independently before the in-class activity phase began. Therefore, the students already have the provision to study in that phase. This is in line with Ausubel & Fitzgerald (1961) related to his opinion about meaningful learning, where the learning process becomes meaningful when students can relate the information they have learned with their previous knowledge. In this study, the in-class activity phase can be meaningful because students have been first equipped with knowledge in the pre-class activity phase through the GLMIQ. Through these media, several aspects of learning independence, such as learning goals, learning materials, learning experiences, and learning evaluation, are accommodated through the process of manipulation of learning media. Specifically, GeoGebra acts as an interactive learning media where students can manipulate all the means contained in the media. Some previous research findings use GeoGebra as a medium of mathematics learning (Batubara, 2019; Kllogjeri, 2010; Kusumah et al., 2020; Septian et al., 2019). Next, the Investigative Question (IQ) aspect guides students in learning the concept they want to learn. Some previous studies have used IQ to help students understand a concept and investigate its properties, such as a study from Arnold and Pfannkuch (2019), who used IQ to improve students' understanding of statistics. Hence, combining those aspects can be an alternative method for increasing students' learning independence in the online mathematics learning.

Indeed, some aspects of this study can be further explored, such as comparing the syntax developed with the syntax of the conventional Flipped Learning model to obtain more comprehensive comparison results or employing mixed methods design to investigate the responses. Further, this research is expected to be useful for stakeholders in developing online mathematics learning policies, mathematics teachers in carrying out mathematics learning online, and researchers as a reference in reviewing students' independence in learning mathematics online.

CONCLUSIONS

This study developed the syntax of the GeoGebra-based Flipped Learning model through the DBR development model consisting of three phases, analyzing and exploration, designing and construction, and also evaluation and reflection. The developed syntax consists of three stages: (1) the pre-class activity stage of GeoGebra-based learning media integrated with investigative questions to assist students in understanding the material taught comprehensively, (2) in-class activity stage where the use of GeoGebra is focused on HOTS-based learning or projects, and (3) post-class activity where teachers deepen students' understanding by enrichment using HOTS-based questions. The implementation of syntax developed in the implementation stage shows that the average value of student independence aspects increases, which means that the GeoGebra-based Flipped Learning syntax can help increase students' independence in learning mathematics. Further research can focus on testing the effectiveness of the syntax by comparing it to the original syntax of Flipped Learning model, or other online-based learning models. In addition, This research has also revealed the students' attitudes toward the implementation of this syntax.

ACKNOWLEDGMENT

The authors would like to express their deepest gratitude to Prof. Dr. Harun Joko Prayitno as the vice rector 1 of Universitas Muhammadiyah Surakarta who has helped the authors get the research grants for this research through Hibah Integrasi Tridharma program (ID GRANT: 975). We would also like to thank Dr. Muhammad Noor Kholid, and Yoga Ratnadi (student), who helped us in the implementation phase in one of the classes.

BIBLIOGRAPHY

Agra, G., Formiga, N. S., Oliveira, P. S. de, Costa, M. M. L., Fernandes, M. das G. M., & Nóbrega, M. M. L. da. (2019). Analysis of the concept of Meaningful Learning in light of the Ausubel's Theory. *Revista Brasileira de Enfermagem*, *72*(1), 248–255. https://doi.org/10.1590/0034-7167-2017-0691

Andriani, T., Ulya, N. H. A., Alfiana, T. P., Solicha, S., Hafsari, S. B. A., & Ishartono, N. (2022). Improving Student's Critical Thinking Skill in Mathematics Through Geogebra-Based Flipped Learning During Pandemi Covid-19: an Experimental Study. *Journal of Medives: Journal of Mathematics Education IKIP Veteran Semarang*, *6*(1), 49. https://doi.org/10.31331/medivesveteran.v6i1.1901

Armstrong, M., Dopp, C., & Welsh, J. (1992). *Design-Based Research*. Open Textbook Networks. design_based_research

Arnold, P., & Pfannkuch, M. (2019). Posing Comparative Statistical Investigative Questions. In *Topics and Trends in Current Statistics Education Research* (pp. 173–195). Springer International Publishing. https://doi.org/10.1007/978-3-030-03472-6_8

Atmojo, S. E., Muhtarom, T., & Lukitoaji, B. D. (2020). The level of self-regulated learning and self-awareness in science learning in the covid-19 pandemic era. *Jurnal Pendidikan IPA Indonesia*, *9*(4), 512–520. https://doi.org/10.15294/jpii.v9i4.25544

Ausubel, D. P., & Fitzgerald, D. (1961). The role of discriminability in meaningful learning and retention. *Journal of Educational Psychology*, *52*(5), 266. https://psycnet.apa.org/record/1964-01964-001

Banditvilai, C. (2016). Enhancing Students' Language Skills through Blended Learning. *Electronic Journal of E-Learning*, *14*(3), 220–229. https://lopes.idm.oclc.org/login?url=http://search.ebscohost.com/login.aspx?direct=true%7B&%7Ddb=ehh%7B&%7DAN=117018543%7B&%7Dsite=eds-live%7B&%7Dscope=site

Bao, L. (2006). Theoretical comparisons of average normalized gain calculations. *American Journal of Physics*, *74*(10), 917–922. https://doi.org/10.1119/1.2213632

Batubara, I. H. (2019). Improving Student's Critical Thinking Ability Through Guided Discovery Learning Methods Assisted by Geogebra. *International Journal for Educational and Vocational Studies*, *1*(2), 116–119. https://doi.org/10.29103/ijevs.v1i2.1371

Bergmann, J., & Sams, A. (2012). *Flip Your Classroom: Reach Every Student in Every Class Every Day*. International Society for Technology in Education. https://doi.org/10.5593/sgemsocial2016/B13/S03.043

Bichelmeyer, B. (2005). The ADDIE model: A metaphor for the lack of clarity in the field of IDT. *IDT Record*, 1–7.

Bikanga Ada, M. (2018). Using design-based research to develop a Mobile Learning Framework for Assessment Feedback. *Research and Practice in Technology Enhanced Learning*, *13*(1). https://doi.org/10.1186/s41039-018-0070-3

Chick, R. C. (2020). Using Technology to Maintain the Education of Residents During the COVID-19 Pandemic. *Journal of Surgical Education*, *77*(4), 729–732. https://doi.org/10.1016/j.jsurg.2020.03.018

Corbeil, J. R., Dick, W., Carey, L., & Carey, J. O. (2005). *EDTC 6321: Instructional Design SUMMER I SYLLABUS*. Pearson. http://www.adobe.com/products/acrobat/readstep2.html

Davies, R. S. (2013). Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course. *Educational Technology Research and Development*, *61*(4), 563–580. https://doi.org/10.1007/s11423-013-9305-6

Fatahillah, A., Puspitasari, I. D., & Hussen, S. (2020). The development of Schoology web-based learning media with GeoGebra to improve the ICT literacy on quadratic functions. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, *5*(3), 304–316. https://doi.org/10.23917/jramathedu.v5i3.10692

Firdausy, A. R., Setyaningsih, N., Ishabu, L. S., & Waluyo, M. (2019). The Contribution of Student Activity and Learning Facilities to Learning Independency and it's Impact on Mathematics Learning Outcomes in Junior High School. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, *1*(2), 29–37. https://doi.org/10.23917/ijolae.v1i2.8104

Flipped Learning Network (FLN). (2014). What Is Flipped Learning ? The Four Pillars of F-L-I-P. In *Flipped Learning Network*. http://www.flippedlearning.org/definition

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). *Educational research: An introduction*. Longman Publishing. https://psycnet.apa.org/record/1996-97171-000

Hermuttaqien, B. P. F., Sata, H. R., & Wadu, L. B. (2019). Efektivitas Media Pembelajaran Geogebra dalam Meningkatkan Pemahaman Konsep Geometri Calon Guru Sekolah Dasar (The Effectiveness of Geogebra Learning Media in Improving Understanding of Geometry Concepts of Prospective Elementary School Teachers). *Jurnal Inspirasi Pendidikan*, *9*(1), 39–44. http://ejournal.unikama.ac.id/index.php/jrnspirasi/article/view/3011

Hidayati, K., & Listyani, E. (2013). IMPROVING INSTRUMENTS OF STUDENTS' SELF-REGULATED LEARNING.

Jurnal Pendidikan Matematika Univertias Negeri Yogyakarta. http://staffnew.uny.ac.id/upload/132296141/penelitian/Pengembangan+Instrumen.pdf
Hohenwarter, M., Jarvis, D., & Lavicza, Z. (2009). Linking Geometry, Algebra and Mathematics Teachers: GeoGebra Software and the Establishment of the International GeoGebra Institute. *International Journal for Technology in Mathematics Education*, *16*(2), 83–87.
Houston, K., & Lazenbatt, A. (1996). A peer-tutoring scheme to support independent learning and group project work in mathematics. *Assessment and Evaluation in Higher Education*, *21*(3), 251–266. https://doi.org/10.1080/0260293960210305
Hubbard, R. S. (1994). How Effective Is Self-Directed Learning at Generating Successful Learning Experiences, and What Is Its Role within Higher Education? *The Annual Meeting of the Teachers of English to Speakers of Other Languages*. https://eric.ed.gov/?id=ED375632
Hwang, G.-J., Lai, C.-L., & Wang, S.-Y. (2015). Seamless flipped learning: a mobile technology-enhanced flipped classroom with effective learning strategies. *Journal of Computers in Education*, *2*(4), 449–473. https://doi.org/10.1007/s40692-015-0043-0
Ilmi, Z., Darma, D. C., & Azis, M. (2020). Independence in Learning, Education Management, and Industry 4.0: Habitat Indonesia during COVID-19. *Journal of Anthropology of Sport and Physical Education*, *4*(4), 63–66. https://doi.org/10.26773/jaspe.201010
Indartono, S. (2019). The Influence of Instructional Syntax to Engage EFL Students in Online Learning Environment. *Indonesian Journal of English Language Teaching and Applied Linguistic*, *4*(1), 121–132. https://eric.ed.gov/?id=EJ1320559
Ishartono, N., Alfian, I. A., & Firdaus, N. (2016). Pelatihan Penggunaan Software Geogebra Pada Materi Bangun Ruang Dimensi Tiga Untuk Guru-Guru Matematika Sekolah Menengah Muhammadiyah Se-Sukoharjo (Training on the Use of Geogebra Software in Three Dimensional Space Building Materials for Muhammadiyah Mid. *The 4th University Research Coloquium 2016*, 264–270. https://doi.org/http://hdl.handle.net/11617/7705
Ishartono, N., Nurcahyo, A., Waluyo, M., Prayitno, H. J., & Hanifah, M. (2022). Integrating Geogebra Into the Flipped Learning Approach To Improve Students ' Self-Regulated Learning During the Covid-19 Pandemic : an. *Journal on Mathematics Education*, *13*(1), 69–85. https://doi.org/10.22342/jme.v13i1.pp69-86
Judith, H., & Markus, H. (2008). *Introduction to GeoGebra*. Geogebra. www.geogebra.org%0A
K, M. E., Thomas, L., & Varghese, A. J. (2020). COVID -19 A Once-in-a-Century Pandemic ? *International Journal of Science and Research (IJSR)*, *9*(3), 2018–2020. https://doi.org/10.21275/SR20307141310
Kemendikbud. (2020). *Surat Edaran Tentang Pelaksanaan Pendidikan dalam masa Darurat Covid-19 (Decree on the Implementation of Education in the Covid-19 Emergency)*. https://www.kemdikbud.go.id/main/blog/2020/03/mendikbud-terbitkan-se-tentang-pelaksanaan-pendidikan-dalam-masa-darurat-covid19
Kholid, M. N., Pradana, L. N., Maharani, S., & Swastika, A. (2022). GEOGEBRA IN PROJECT-BASED LEARNING (GEO-PJBL): A DYNAMIC TOOL FOR ANALYTICAL GEOMETRY COURSE. *Journal of Technology and Science Education*, *12*(1), 112–120.
Klemer, A., & Rapoport, S. (2020). Origami and GeoGebra activities contribute to geometric thinking in second graders. *Eurasia Journal of Mathematics, Science and Technology Education*, *16*(11). https://doi.org/10.29333/EJMSTE/8537
Kllogjeri, P. (2010). GeoGebra: A global platform for teaching and learning math together and using the synergy of mathematicians. *Communications in Computer and Information Science*, *2*(3), 681–687. https://doi.org/10.1007/978-3-642-13166-0_95
Koivisto, J.-M., Hannula, L., Boje, R. B., Prescott, S., Bland, A., Rekola, L., & Haho, P. (2018). Design-Based Research in Designing the Model for Educating Simulation Facilitators. *Nurse Education in Practice*, *29*, 206–2011. https://doi.org/10.1016/j.nepr.2018.02.002
Kristanto, Y. D., Amin, S. M., & Khabibah, S. (2016a). The Development of Investigative Learning Materials Using Computer Assisted Instruction in the Topic of Reflection for Grade VII. *JRAMathEdu (Journal of Research and Advances in Mathematics Education)*, *1*(2), 172–182. https://doi.org/10.23917/jramathedu.v1i2.4828
Kristanto, Y. D., Amin, S. M., & Khabibah, S. (2016b). The Development of Investigative Learning Materials Using Computer Assisted Instruction in the Topic of Reflection for Grade VII. *Journal of Research and Advances in Mathematics Education*, *1*(2), 172–182. http://journals.ums.ac.id/index.php/jramathedu
Kusumah, Y. S., Kustiawati, D., & Herman, T. (2020). The effect of geogebra in three-dimensional geometry learning on students' mathematical communication ability. *International Journal of Instruction*, *13*(2), 895–908. https://doi.org/10.29333/iji.2020.13260a
Kusumaningrum, D. E., Budiarti, E. M., Triwiyanto, T., & Utari, R. (2020). The Effect of Distance Learning in an

Online Learning Framework on Student Learning Independence during the Covid-19 Pandemic. *Proceedings - 2020 6th International Conference on Education and Technology, ICET 2020*, 182–185. https://doi.org/10.1109/ICET51153.2020.9276564

Latorre-Cosculluela, C., Suárez, C., Quiroga, S., Sobradiel-Sierra, N., Lozano-Blasco, R., & Rodríguez-Martínez, A. (2021). Flipped Classroom model before and during COVID-19: using technology to develop 21st century skills. *Interactive Technology and Smart Education*. https://doi.org/10.1108/ITSE-08-2020-0137

Liaw, S. S., Huang, H. M., & Chen, G. D. (2007). An activity-theoretical approach to investigate learners' factors toward e-learning systems. *Computers in Human Behavior*, *23*(4), 1906–1920. https://doi.org/10.1016/j.chb.2006.02.002

Lin, H. C., Hwang, G. J., & Hsu, Y. D. (2019). Effects of ASQ-based flipped learning on nurse practitioner learners' nursing skills, learning achievement and learning perceptions. *Computers and Education*, *139*(April), 207–221. https://doi.org/10.1016/j.compedu.2019.05.014

Little, D. (1996). Learner Autonomy: Some Steps in the Evolution of Theory and Practice. *TEANGA: The Irish Yearbook of Applied Linguistics*. https://files.eric.ed.gov/fulltext/ED414746.pdf

Littlewood, W. (1999). Defining and developing autonomy in East Asian contexts. *Applied Linguistics*, *20*(1), 71–94. https://doi.org/10.1093/applin/20.1.71

Magomedov, I. A., Khaliev, M. S. U., & Khubolov, S. M. (2020). The negative and positive impact of the pandemic on education. *Journal of Physics: Conference Series*, *1691*(1). https://doi.org/10.1088/1742-6596/1691/1/012134

McHugh, M. L. (2012). Lessons in biostatistics interrater reliability : the kappa statistic. *Biochemica Medica*, *22*(3), 276–282. https://hrcak.srce.hr/89395

McKenney, S., & Reeves, T. C. (2014). Educational design research. In Handbook of research on educational communications and technology (pp. 131-140). Springer, New York, NY.

Meltzer, D. E. (2002). The relationship between mathematics preparation and conceptual learning gains in physics: A possible "hidden variable" in diagnostic pretest scores. *American Journal of Physics*, *70*(12), 1259–1268. https://doi.org/10.1119/1.1514215

Ministry of Education (MOE). (2020). Surat Edaran Tentang Pelaksanaan Pendidikan dalam masa Darurat Covid-19 (Decree on the Implementation of Education in the Covid-19 Emergency). https://www.kemdikbud.go.id/main/blog/2020/03/mendikbud-terbitkan-se-tentang-pelaksanaan-pendidikan-dalam-masa-darurat-covid19

Murillo-Zamorano, L. R., Sánchez, J. Á. L., & Godoy-Caballero, A. L. (2019). How the flipped classroom affects knowledge, skills, and engagement in higher education: Effects on students' satisfaction. *Computers and Education*, *141*(June). https://doi.org/10.1016/j.compedu.2019.103608

Nerantzi, C. (2020). The use of peer instruction and flipped learning to support flexible blended learning during and after the COVID-19 pandemic. *International Journal of Management and Applied Research*, *7*(2), 184–195. https://e-space.mmu.ac.uk/626131/3/flipped classroom peer instruction 6July20.pdf

Nisiyatussani, Ayuningtyas, V., Fathurrohman, M., & Anriani, N. (2018). GeoGebra applets design and development for junior high school students to learn quadrilateral mathematics concepts. *Journal on Mathematics Education*, *9*(1), 27–40. https://doi.org/10.22342/jme.9.1.4162.27-40

Nuraeni, Z., Indaryanti, I., & Sukmaningthias, N. (2021). Pengembangan Perangkat Pembelajaran Bercirikan CTL Berbantuan GeoGebra Menggunakan Model Flipped Learning (Development of GeoGebra Assisted CTL Learning Tools Using the Flipped Learning Model). *Jurnal Elemen*, *7*(1), 56–67. https://doi.org/10.29408/jel.v7i1.2723

O'Flaherty, J., Phillips, C., Karanicolas, S., Snelling, C., & Winning, T. (2015). Erratum: The use of flipped classrooms in higher education: A scoping review (The Internet and Higher Education (2015) 25 (85-95)). *Internet and Higher Education*, *27*, 90. https://doi.org/10.1016/j.iheduc.2015.05.001

Purwanto, A., Fahlevi, M., Budi Santoso, P., Setyo Radyawanto, A., & Anwar, C. (2020). Exploring the Covid-19 Pandemic Impact on the Indonesian Students Performance. *Journal of Critical Review*, *7*(15), 2020–2035.

Rahiem, M. D. H. (2020). The emergency remote learning experience of university students in Indonesia amidst the COVID-19 crisis. *International Journal of Learning, Teaching and Educational Research*, *19*(6), 1–26. https://doi.org/10.26803/ijlter.19.6.1

Reeves, T. (2006). Design research from a technology perspective. In *Educational design research* (pp. 64–78). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9780203088364-13/design-research-technology-perspective-thomas-reeves

Rotellar, C., & Cain, J. (2016). Research, perspectives, and recommendations on implementing the flipped classroom. *American Journal of Pharmaceutical Education*, *80*(2), 1–9. https://doi.org/10.5688/ajpe80234

Sakai, S., Takagi, a, & Chu, M. (2010). Promoting Learner Autonomy: Student Perceptions of Responsibilities in a Language Classroom in East Asia. *Educational Perspectives*, *43*(1), 12–27.

http://files.eric.ed.gov/fulltext/EJ912111.pdf

Saputra, E., & Fahrizal, E. (2019). The development of mathematics teaching materials through geogebra software to improve learning independence. Malikussaleh Journal of Mathematics Learning (MJML), 2(2), 39-44. https://doi.org/10.29103/mjml.v2i2.1860

Septian, A., Inayah, S., Suwarman, R. F., & Nugraha, R. (2019). GeoGebra-Assisted Problem Based Learning to Improve Mathematical Problem Solving Ability. In M. Irfan (Ed.), *Proceedings of the SEMANTIK Conference of Mathematics Education (SEMANTIK 2019)* (Vol. 467, Issue Semantik, pp. 67–71). Atlantis Press. https://doi.org/10.2991/assehr.k.200827.119

Sharma, N., Lau, C. S., Doherty, I., & Harbutt, D. (2015). How flipped the medical classroom. *Medical Teacher*, *37*(4), 327–330. https://doi.org/10.3109/0142159X.2014.923821

Sierpinska, A., Bobos, G., & Knipping, C. (2008). Sources of students' frustration in pre-university level, prerequisite mathematics courses. In *Instructional Science* (Vol. 36, Issue 4). https://doi.org/10.1007/s11251-007-9033-6

Slamet, S., Amrullah, A. M. K., Sutiah, S., & Ridho, A. (2021). Differences in the Experience of Lecturers and Students on Distance Learning In Higher Education in Indonesia : Case Study in the Pandemic of Covid-19. *Systematic Reviews in Pharmacy*, *12*(1), 742–747. https://doi.org/10.31838/srp.2021.1.108

Smith, M. S., & Stein, M. K. (1998). Selecting and Creating Mathematical Tasks : From Research to Practice Knowing a Good Task When You See One Reflection : *Mathematics Teaching in the Middle School*, *3*(February), 344–350.

Somthane, P. N., Landge, M. M., & Joshi, D. A. (2020). Corona Virus : Don ' t be Afraid ; Be Safe. *International Journal of Science and Research*, *9*(4), 21–25. https://doi.org/10.21275/SR20329200113

Subakri, & Annizar, A. M. (2021). The effects of covid-19 in learning: Effective and efficient online learning models of mathematical statistics and real analysis from the students' perspective. *Journal of Physics: Conference Series*, *1836*(1), 1–11. https://doi.org/10.1088/1742-6596/1836/1/012048

Suharsimi, A. (2006). Prosedur penelitian suatu pendekatan praktik. *Jakarta: Rineka Cipta*.

Sutama, Prayitno, H. J., Ishartono, N., & Sari, D. P. (2020). Development of Mathematics Learning Process by Using Flipped Classroom Integrated by STEAM Education in Senior High School. *Universal Journal of Educational Research*, *8*(8), 3690–3697.

Tanti, Maison, Syefrinando, B., Daryanto, M., & Salma, H. (2020). Students' self-regulation and motivation in learning science. *International Journal of Evaluation and Research in Education*, *9*(4), 865–873. https://doi.org/10.11591/ijere.v9i4.20657

Ustun, A. B., & Tracey, M. W. (2020). An effective way of designing blended learning: A three phase design-based research approach. *Education and Information Technologies*, *25*(3), 1529–1552. https://doi.org/10.1007/s10639-019-09999-9

Usuki, M. (2000). *Promoting learner autonomy : Learning from the Japanese language learners ' perspectives*. https://archive.org/details/ERIC_ED450588

Wan Ahmad, W. N. A., Sufahani, S. F., Zinober, A., Sudin, A. M., Ismoen, M., Maselan, N., & Ishartono, N. (2019). Nonstandard optimal control problem: Case study in an economical application of royalty problem. *International Journal of Advances in Intelligent Informatics*, *5*(3). https://doi.org/10.26555/ijain.v5i3.357

Wang, F., & Hannafin, M. J. (2005). Designing Technology Enhanced Learning Environments. *Educational Technology Research and Development*, *53*(4), 5–23. https://doi.org/10.4018/978-1-878289-59-9.ch016

Worldometer. (2020). *COVID-19 CORONAVIRUS PANDEMIC*. Worldometer. https://www.worldometers.info/coronavirus/?utm_campaign=homeAdvegas1?

Yamin, M., Saputra, A., & Deswila, N. (2020). Enhancing Critical Thinking in Analyzing Short Story "The Lazy Jack" Viewed from Identity Theory. *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, *3*(1), 30–39. https://doi.org/10.23917/ijolae.v3i1.9948

Yustina, Syafii, W., & Vebrianto, R. (2020). The effects of blended learning and project-based learning on pre-service biology teachers' creative thinking skills through online learning in the COVID-19 pandemic. *Jurnal Pendidikan IPA Indonesia*, *9*(3), 408–420. https://doi.org/10.15294/jpii.v9i3.24706