Enhancing Students' High-Order Thinking Skills through STEM-Blended Learning on Kepler's Law During Covid-19 Outbreak

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Abstract

This study aimed to examines the effectiveness of the implementation of STEM-Blended learning to enhance high school students' high-level thinking skills on Kepler law concept during covid-19 outbreak. The method used in this study is a quasi-experimental method. This study used two class groups including the experimental class and the control class. This study was conducted at one of high schools in Indonesia. The students' higher-order thinking skills for the experimental class was included in the medium category with a percentage of achievement of 75%. However, in the control class, it was included in the medium category with a rate of 61%. The results showed that there were significant differences between experimental and control classes with the value $.0015 < 0.05$, meaning that the implementation of STEM-Blended learning is effective to enhance high school students' high-level thinking skills on Kepler law concept. This findings will be usefull for the development of STEM Education during Covid-19 outbreak.

INTRODUCTION

Through technological help, the covid-19 pandemic given an insight of the future continuation of the field of education (Etika, 2020). However, technology will never be able to replace instructors' roles or learning exchanges between students and teachers since education is about gaining information and values, cooperating, and being competent (Rahiem, 2020). This pandemic scenario is a measure for every person's inventiveness in using technology to advance the educational process (Mulyanti, 2020).

With Indonesia's scenario, which includes hundreds of islands, online learning is a problem for the globe of education (Putri, 2020). Technology may be utilized to give internet connection in distant places where technological items are still considered a luxury without access to the internet (Hidayati, 2020). Access to the internet is a difficulty for all parties. At this moment, we should try harder to introduce techniques to solve the genuine challenges that teachers and students who are less privileged in terms of funding and technology face in distant places face (Kusumawati, 2020; Taufik, 2020).

During the Covid-19 pandemic, there are indeed many different things that are happening in this life. One of these changes occurs in education, where learning activities must be carried out online or online (Amir, 2020; Mailizar, 2020). Indonesia itself, which is also affected by the coronavirus outbreak, inevitably has to carry out education online (Nisa, 2020). Unfortunately, in this online learning, there are many obstacles or problems. Indonesia's initial educational challenge during the epidemic was a lack of preparedness in terms of educational infrastructure (Siron, 2020). Perhaps the city's children can still be educated online or online without problems. However, this does not apply to areas or provinces that do not have an internet network and cities. To do this online learning, you will need not only an internet network, but also a device in the form of a laptop or smartphone. Not all kids in Indonesia, especially in the area where this equipment is, so the problem arises here.

The quota issue is another issue that arises as a result of this online learning method. This online study does necessitate the purchase of a quota. Many middle- and lower-class parents find it difficult to get rations from here. This online study does necessitate the purchase of a quota. Many middle- and lower-class parents find it difficult to get rations from here. This online study does necessitate the purchase of a quota. Many middle- and lower-class parents find it difficult to get rations from here.

Serious issues might also emerge throughout the online learning process. Because online learning does not need students to interact in person in class, the teacher's explanation will be less effective (Huang, 2020). As a result, a significant number of pupils are unable to comprehend the information provided. Students with private tutors may be able to go deeper into the content to better grasp it afterwards. However, private tutors are not available to all pupils in Indonesia. When it comes to children with special needs or impairments, online learning will just exacerbate the issues they already have (Rasmitadila, 2020).

Finally, children's mental health and seriousness in education were determined to be issues in Indonesia's online learning throughout the epidemic. There are a lot of kids that underestimate the value of online learning. Rather than taking studying seriously, many people use the internet to pass the time on their vacation. When this is combined with the fact that many teachers offer a large number of assignments, students become less serious about learning. They believe that creating projects is the only way to learn online.

At the moment, the pandemic is a problem for the development of technological inventiveness, knowledge transfer and the right transmission of learning. This challenge is also a chance to help students and students become proficient in technology for the 21st century. Higher thinking abilities as a result of schooling are the important talents for the 21st century. This epidemic time can establish and instill in numerous webinars and online classrooms the habit of being independent students. Students can also work together to resolve learning challenges and confront actual concerns.

During the Covid-19 pandemic, namely the new-normal period, one of the most suitable learning methods is the blended learning method. Blended learning is a mixed learning pattern between education in class (face to face) and online (webinars, LMS) (Rasheed, 2020). However, during this pandemic, the online method used was both synchronous and asynchronous multimedia.

Blended Learning is a component of the ongoing fusion of two prototypical learning environments. On one side, we have the traditional face-to-face learning environment, which has existed for millennia. On the other side, we have dispersed learning settings that have started to develop and spread in exponential ways as new technologies have increased the opportunities for remote communication and engagement (Pool and Byatt, 1996). Chat and video conferencing are examples of

synchronous online learning (Zydney, 2019). Synchronous learning refers to any real-time learning tool, such as instant messaging, that allows students and teachers to ask and answer questions in real time (Zydney, 2020). Students that participate in synchronous learning can engage with other students and their teachers throughout the class, rather than learning alone (Wang, 2018). The major advantage of synchronous learning is that it helps students to avoid feeling alone by allowing them to communicate with others while studying. Students must set up certain time periods to attend live teaching sessions or study online in real-time, therefore synchronous learning is not very flexible.

Asynchronous learning, on the other hand, can take place even if the student or instructor is not connected to the internet (West *et al.*, 2017). Asynchronous e-learning includes courses and communications supplied over the internet, e-mail, and messages posted on community forums. Instead of accessing the internet just for interactive lessons, students would generally finish their work and utilize the internet as a resource. Without having to worry about schedule conflicts, a student may pursue the program at their own speed. This is probably the best option for those who want to browse for subjects freely and enjoy relaxing in each lesson plan in the curriculum. Those who lack the drive to complete activities on their own, on the other hand, may believe that asynchronous learning is ineffective. Because there is no natural interactive learning environment, asynchronous learning can lead to isolation (Chen, Breslow and DeBoer, 2018).

In its implementation, teachers need to concoct blended learning in each educational institution because blended learning must be different. After all, it must be student-oriented, as required. The focus is on providing authentic materials and guidelines (Shu, 2018). The multimedia position in blended learning is not a goal but a way to achieve goals to facilitate learning, which is difficult when delivered directly (Philipsen, 2019). Teachers must utilize and create technology to complement the 21st-century skills required a learning approach to improve students' higher-order thinking. This study's renewal examines STEM-Blended learning to enhance high school students' high-level thinking skills on Kepler law material. The STEM-Blended Learning model used is very supportive and influential for students' higher-order thinking achievement. With this, students listen to and receive learning material from the teacher. Still, students can also play a role and be directly involved to understand what students learn efficiently.

The development of technology and information in recent times has increased. Indonesia, being a huge country with a richness of natural resources and a vast population, should play a key part in its growth. Therefore, to make this happen, Indonesia must adjust its education pattern. Indonesia must implement education that includes science, Technology, Engineering, and Math (STEM). The aspects of science, technology, engineering, and math (STEM) are the foundation for developing the latest advanced technologies. At first glance, STEM-based learning only focuses on aspects of learning science in science, technology, engineering, and mathematics. But on a broader level (Haryadi and Pujiastuti, 2020).

STEM-educated students are expected to have a blend of sophisticated and soft abilities. Communication, teamwork, problem-solving, leadership, creativity, and other aspects of the learning process are all addressed through active learning (Parno, 2020). For this reason, it is appropriate for the economic policy agenda to focus on improving the quality of human resources, which have high abilities in research, innovation, and commercialization, as well as in response to technological developments.

When comparing education in Indonesia, it is still overshadowed by various classic problems, such as the chaos in determining the curriculum for primary education. However, this incident could become a joint momentum to improve the education system in Indonesia. The first thing that needs to be done by the state is to realize the importance of STEM-based learning and increase people's attention and understanding of STEM education. The STEM learning method must then be included in the educational curriculum to make a strong policy foundation.

It should be remembered that Indonesia is currently entering an era of free competition, which began with the ASEAN Economic Community, allowing foreign human resources to compete with local human resources more freely. Urgency in a STEM lesson which calls for the cooperation of students (Ngan *et al.*, 2020). It is likewise pertinent for instructors to inspire students' energetic involvemen. In the future, the high economic growth will be meaningless if local human resources are excluded and replaced by foreign workers. With this awareness, stakeholders, including students, teachers, and parents, should be more active in learning STEM. So the keyword is increasing awareness of the need for STEM in facing the future

Blended Learning is learning by involving synchronous learning with asynchronous learning (Pujiastuti and Haryadi, 2020). Blended learning is a combination of the characteristics of traditional education and an electronic learning environment (McCutcheon, 2018). Blended learning can motivate itself internally and control their learning ability anywhere, anytime and create student independence (Green, 2018). In Blended Learning, six elements must be present, namely: (1) face-to-face (2) independent learning, (3) application, (4) tutorials, (5) cooperation, and (6) evaluation. In addition to the six elements above, blended learning as a learning method also has its characteristics (Ghazal, 2018; Leite, 2018; Popovic, 2018). The understanding that integrates multiple ways of delivery, instructional methods, and learning styles are the following qualities (Lazarinis, 2019).

Additionally, more particular Blended Learning characteristics, such as (1) separating learning activities from learning activities. (2) During the learning process, students and educators are separated by geography, time, or some combination of these factors. (3) Because students and educators are separated during the learning process, learning media such as print and electronic media, telephone, radio, video, television, and computers aid

communication between them. (4) Services, such as resource learning centers or learning resource centers, instructional materials, and learning infrastructure, are offered to both students and instructors (Eaton, 2018; Tikadar, 2018; Aguilar-Rodríguez, 2019). As a result, neither students nor educators must focus on their personal needs during the teaching and learning process (Stites, 2019).

Using blended learning during the Covid-19 epidemic has numerous benefits, including: (1) students are free to learn subject matter freely using materials available online. (2) Outside of face-to-face hours, students can conduct conversations with the teacher or other students. (3) Teachers can use the internet to add enrichment materials. (4) Students might be asked to read the content by their professors. (5) Students are able to share files with one another (Siripongdee, 2020). However, entering the new-normal blended learning model alone is not enough to improve students' high-order thinking skills. There needs to be an intake approach in learning—one of the learning approaches used in STEM.

STEM refers to the interdisciplinary integration of four disciplines, namely science, technology, engineering, and mathematics, in which real-world settings and problem-based

learning are used (Mohd Najib, Mahat and Baharudin, 2020). STEM learning includes a process of critical thinking, analysis, and collaboration (Sumarni *et al.*, 2020). Students apply science, technology, engineering, and mathematics techniques and ideas in real-world situations to help students build skills and capabilities for education, profession, and community.

In STEM, students learn skills and knowledge simultaneously (Saw *et al.*, 2019). Things that are different from the STEM aspect will require a connecting line that allows the four disciplines to be studied and applied simultaneously in learning. A good innovation is when students can connect all aspects of STEM and assemble four interdisciplinary STEM aspects to solve a problem (Awang *et al.*, 2020). The four STEM disciplines, namely: (a) Science is the study of natural laws in physics, chemistry, biology, and medicine, as well as the application of facts, principles, ideas, and convection in these fields. (b) Technology is a talent or a system that regulates society, organizations, and knowledge, or it may be characterized as a result of science and engineering at its most basic level. (c) Engineering is the application of engineering knowledge to a problem by combining scientific and mathematical principles with technical instruments. (d) Mathematical knowledge involves logical reasons to link quantities, spaces, and numbers. (Ng, 2018; Hong, 2019; Kranzfelder, 2019). When the four domains of knowledge are incorporated into the learning process, the experience becomes more meaningful. Students who learn using the STEM method get experience in integrating all aspects of their education at the same time—engineering knowledge by applying scientific and mathematics ideas as well as technology tools to solve a problem.

Character is the capacity of pupils to recognize a concept or information in a situation in STEM learning. STEM, like Kepler's Law, allows students to utilize science to show a law or idea of Kepler's Law. In education, the STEM learning paradigm seeks to educate students to compete and work in their domains of competence. STEM (science, technology, engineering, and mathematics) education is an educational method that combines science, technology, engineering, and mathematics by concentrating the educational process on addressing real-world or professional issues (Zhao, 2020). STEM education allows instructors to show students how science, technology, engineering, and integrated mathematics ideas, concepts, and processes are employed in the production of goods, activities, and structures that

are used in daily situations (Sun, 2020). STEM (science, technology, engineering, and mathematics) instruction for children places science, technology, engineering, and mathematics in a natural framework that connects schools, the workplace, and the world at large (Sulaeman *et al.*, 2021). STEM literacy is required of students as they compete in the emerging knowledge-based economy (El Islami and Nuangchalerm, 2020). STEM refers to the knowledge and abilities needed to acquire and apply scientific, economic, and social expertise, as well as design and build machines, equipment, systems, and materials. It is a technique that is both economically and environmentally beneficial to people (Arai, 2020). STEM oriented student learning employs science, technology, engineering and math in a natural environment which links schools, the workplace and the world of science (Wiseman, 2020).

STEM integrated education focuses not only on developing students' abilities in science, technology, engineering, and mathematics but also on cultivating high-order thinking skills such as the discovery of innovations in technology to solve a problem (Nugent, 2019). STEM education is an integrated pattern to develop human resources' quality by the skills demands of the 21st century (Abdurrahman, 2019b). The learner's critical and creative thinking skills have been shown via the use of the STEM method. STEM-based education may motivate students to build, develop, use technology, understand, manipulate and practice information and use it. (Abdurrahman, 2019a).

In this study, we combined the blended learning model with the STEM learning approach (STEM-BL) to measure the achievement of high-order thinking skills in high school students. HOTS includes the ability to think critically, logically, reflectively, metacognitively, and creatively. This ability underlies a person to solve a problem. In the bloom taxonomy, HOTS is included in analyzing, evaluating, and creating, no longer in the process of remembering, understanding, and applying (Muthmainnah, 2019). This explains that HOTS has a goal of solving problems based on exploring existing knowledge and new information.

HOTS is thinking at a higher level than remembering facts, repeating facts, or applying rules/formulas/procedures (Singh, 2020). HOTS requires explaining something with a point. The obtained facts must be understood, connected with other facts, grouped, manipulated, and processed into a new way and applied to get new solutions to a problem (Akhsan, 2020). HOTS is when a person receives new information, and the data is stored

for further processing (Sinta, 2020). From that information, possible answers are sought that can solve a problem in that situation. Therefore, high order thinking skill (HOTS) will occur when someone can find viable solutions to questions based on the processing of new information obtained with the knowledge or story that has been received. Of course, the data obtained is processed and needs to be developed to get an excellent conclusion to solve the problems.

Based on the HOTS approach and understanding, it can be concluded that the HOTS approach is an essential learning process that requires students to be able to process their knowledge with new information to find solutions to the problems given (Saritepeci, 2019). The HOTS approach can make students think more creatively and critically. Through this approach, students will play an active role in finding new information from various sources. The teacher acts as a facilitator who helps students to be able to process data to draw conclusions or solutions to the problems given finally. The HOTS approach is an innovation in education to require students to take an active role in classroom learning. Learning using the HOTS approach will help students be more independent and confident in solving a given problem (Carroll, 2020; Dewi, 2020).

This is because students will seek and process information according to their respective abilities.

The criteria in learning using the HOTS approach are: 1) students can evaluate problems based on the specified criteria, 2) students can show uncertain information, 3) students can draw a temporary conclusion based on existing information, 4) students can evaluate provisional decisions for can draw more logical findings, 5) students can draw broad and analytical results so that they can explain the cause and effect of a given problem (Mawardi, 2020; Wahidah, 2020). Based on the characteristics mentioned, the HOTS approach in learning is each student's process when they begin to formulate, process, and conclude the situation. In problem-solving, every student is introduced to knowing a problem before analyzing important information on the case. The ability to process information and mix students' knowledge can also influence ambiguity in concluding. Based on Bloom's Taxonomy, HOTS approach indicators include analyzing, evaluating, and creating (Magas *et al.*, 2017).

Table 1. HOTS indicator

No.	Indicator		Information
1.	Analyze		An analysis is a technique to distinguish, organize data to look for relationships between one data and another and interpret its meaning. In the analyzing stage, students will learn to analyze a given problem. From this understanding, it can be seen that three elements make up the analysis, namely differentiating, organizing, and attributing.
	a.	Differentiating	Distinguishing occurs when students can sort data into relevant data to less relevant data. The goal is to sort data that can be used as problem solvers or data supporting information in concluding.
	b.	Organizing	Organizing is grouping related data. Also, these data can function together in one structure. In organizing, students must be able to distinguish the relationship from the data that has been collected.
	c.	Attributing	Data that has been organized will be underlined by the parts that are the core of the problems given. At this stage, students will find the essence of the question for which a solution will be sought.
2	Evaluate		Evaluating is checking the solution obtained. By assessing, students can criticize the answer to a problem. There are two aspects contained in the evaluation, namely reviewing and critiquing.
	a.	Checking	When the results have been obtained, students will double-check the consistency of the products. Apart from checking the results, students can also check the complete process's effectiveness to get more consistent and effective results.
	b.	Critiquing	Criticism occurs when students find inconsistent results. Also, students can criticize the process that is less efficient in drawing a solution to a problem.
3	Create		Creating is compiling the information obtained to collect a completion plan whose goal is to get results. The results obtained are the actual results, not the works of estimates or provisional hypotheses. In this stage, students are led to be able to find a solution to the problem. Also, students can explain the cause and effect of the situation given. The essential aspects of creation are generating, planning, and producing.
	a.	Generating	The solution to be taken is a composition of the previously obtained hypotheses. Information and assumptions are compiled to find the final answer to a given problem.
	b.	Planning	Planning functions to determine the ways or steps to be taken to find a solution. Students will decide for themselves the steps that will be used to solve the given problem. The goal is to make it easier for students to find solutions.
	c.	Producing	At this stage, students will create a product based on the results that have been given. Of course, the resulting product must match the description of the results provided. In this final stage, students can explain in detail and a structured manner about the problems' causes and effects.

METHOD

This research is quantitative, and the method used is a quasi-experimental research method (Creswell, 2013). This study used two class groups, namely the experimental class and the control class. The implementation of this research was from March 2020 to June 2020. The

research location was located in Cikulur high school, Rangkas-Banten-Indonesia. The area is in rural Banten province. This is done to determine the ability of high-order thinking skills in village students. The sample was selected based on the knowledge above the average physics learning outcomes and then assigned into two class groups. The design of this study used a non-equivalent control group design. In this study, there are pretest, treatment, and post-test, along with a picture of the research design pattern. Detailed research procedures are shown in Figure 1. Moreover, the stages in the STEM-blended learning process can be shown in Figure 2 and the steps for using blended learning can be seen in Figure 3.
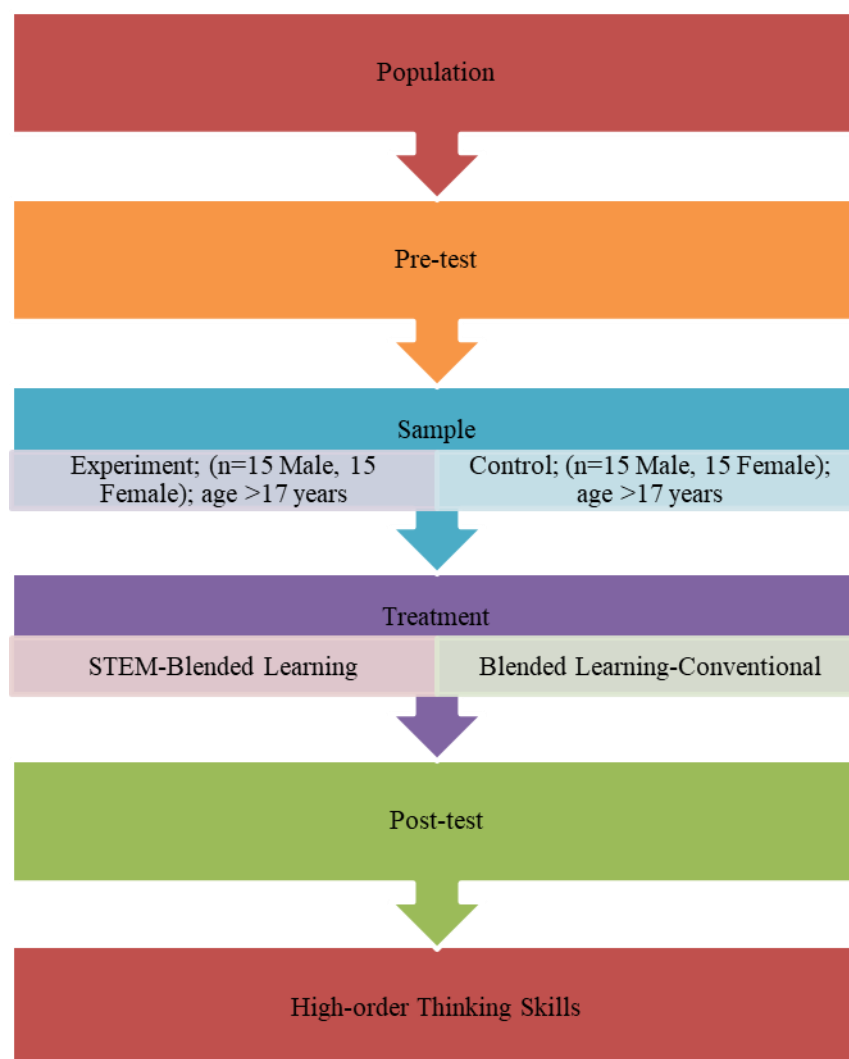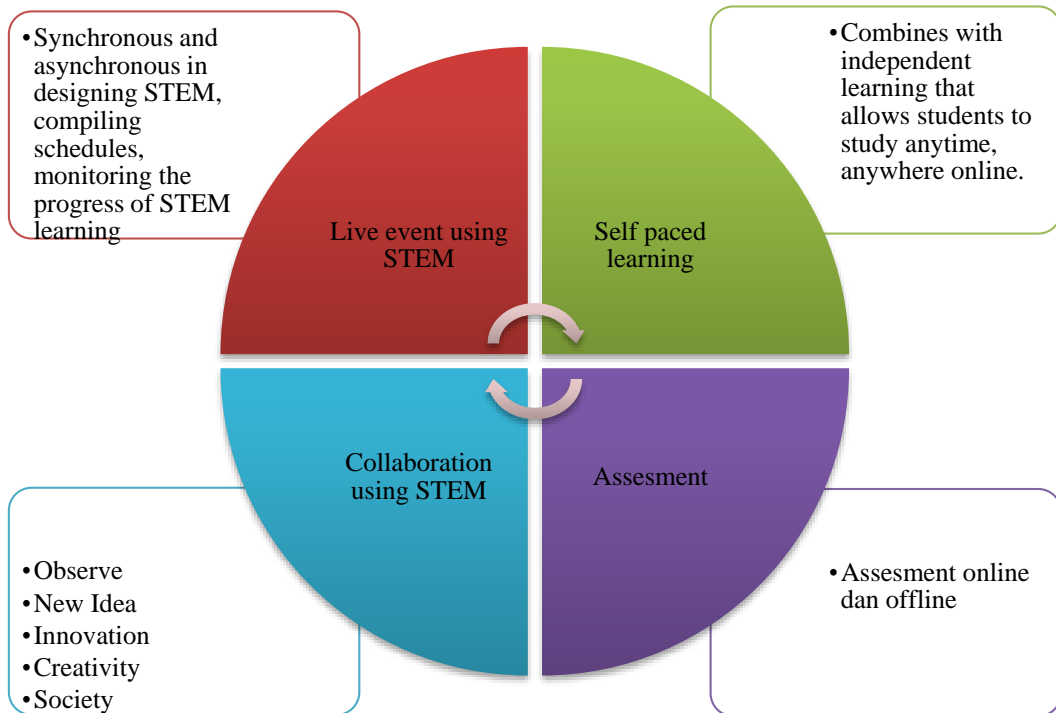

Figure 1. Research design
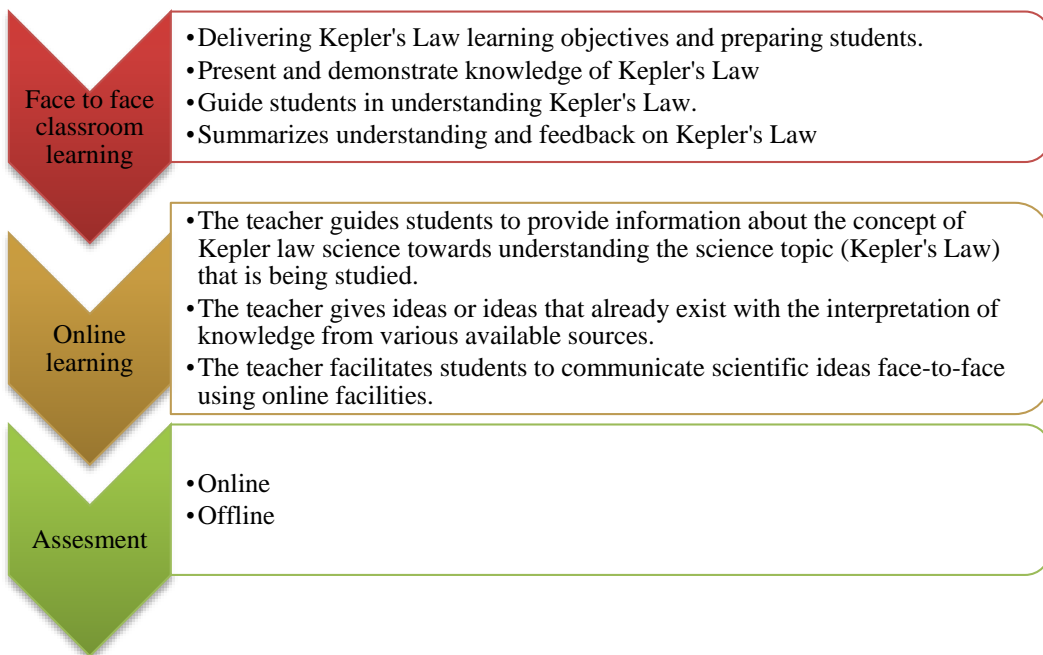
Figure 2. STEM-blended learning

Figure 3. Blended learning

Data Analysis

N-Gain

This analysis is used to see the difference in higher-order thinking skills (HOTS) in the experimental and control classes. Evaluate from the increase in the score of each student between the pretest and post-test. This data is called the gain, following the n-gain formula (Hake, 1998).

$$N - g = \frac{X_{post} - X_{pre}}{X_{max} - X_{pre}} \qquad (1)$$

Explanation:

Ng = n-gain

X_{pre} = pretest score

X_{post} = posttest score

X_{max} = maximum score

The average N-gain is calculated by dividing the number of N-gain of each individual by the number of individuals. The interpretation of N-gain is presented in Table 2.

Table 2. Interpretation of N-gain values

N-gain score	Classification
$g \geq 0.7$	High
$0.7 \leq g \leq 0.3$	Is being
$g < 0.3$	Low

Normality Test

In this study, the normality test used the Shapiro Wilk test. The data normality test is carried out before testing the Hypothesis, which aims for the data that has been collected is normally distributed or taken from the average population. To make testing easier, researchers used the SPSS Version 16 application to analyze this instrument's normality.

The basis for decision making in the normality test, namely:

a. If sig. (significance) > 0.05, then the data is normally distributed.

b. If sig. (significance) <0.05, then the data is not normally distributed and must perform non-parametric tests.

Homogeneity Test

Homogeneity is used to determine whether several variants in the population are the same or not. As a test criterion, if the value is sig. > 0.05, it can be concluded that the variants of two or more groups are the same—Vice versa. After the pretest, the homogeneity test was carried out, and post-test data from the study sample were obtained. In this study, the homogeneity test was calculated using one-way ANOVA with the SPSS (Statistical Package for Social Science) program version 16.

T-test

The T-test was conducted to determine the student's achievement ability using the Parametric Independent Sample T-test. If the previous data were normally distributed, the data were processed using the Mann Whitney test if the data were not normally distributed. The Mann Whitney test is carried out with the same objective as the T-test using the Independent Sample T-test; only the Mann Whitney test is carried out for non-parametric tests for data that are not normally distributed.

Hypothesis Testing

Hypothesis testing in this study uses the Mann Whitney test with a significance level <0.05. The Hypothesis H_1 is accepted, and H_o is rejected. If the significance level is> 0.05, then the Hypothesis H_1 is rejected, and H_o is received; the following is the Hypothesis in this study.

—H_o: The achievement of High Order Thinking Skills of students who carry out learning using the STEM-blended learning model is no better than learning using the blended learning model only.

—H_1 : The achievement of High Order Thinking Skills of students who carry out learning using the STEM-blended learning model is better than learning using the blended learning model only.

RESULTS AND DISCUSSION
Data on the results of the pretest and post-test

Based on the implementation, The data of the pre-test and post-test were can be seen in Table 3. Moreover, the normality of the pre-test and post-test were can be seen in Table 4 and the homogenity of the pre-test and post-test were can be seen in Table 5. Additionally, N-Gain is can be seen in Tabel 6.

Table 3. Data of Pretest and Posttest Results

NO	Data spread	Pretest		Post-test	
		Class experiment	Class control	Class experiment	Class control
1	Score the highest	20	25	65	55
2	Score Lowest	15	10	30	20
3	Average	15	20	40	35
4	Standard Deviation	8	7	11	11

Table 4. Normality test data using Shapiro Wilk

No.		Shapiro Wilk		
		Statistics	Df	sig
1	Pretest experiment	621	20	.017
2	Posttest experiments	635	20	.024
3	Control pretest	603	20	.006
4	Posttest control	611	20	.021

Table 5. Mann Whitney Difference Test Data

Mann-Whitney U	Wilcoxon W	Z	Sig. (2-tailed)
Learning outcomes .400	.480	-4.756	.0015

Table 4 shows the value <0.05, which means the data above is not normally distributed. Table 5 shows the significance <0.05, which means that the Hypothesis H_1 in this study is accepted.

Table 6. Comparison of Enhanced Ability using N-Gain

Class	N-Gain
Experiment Class	0.31
Control Class	0.19

In the implementation of this research, students started learning online using group chat via WhatsApp, and this activity was carried out in addition to the pandemic period. Still, this activity was also a requirement of the Blended Learning learning model. In this group, students are given the freedom to discuss and exchange ideas about the learning material discussed so that they can participate in this online discussion activity. Unfortunately, some students cannot participate in this online discussion activity regularly because they do not attend the discussion forum. After several weeks of conducting this online discussion activity, the researcher gives a post-test to determine the increase in student HOTS achievement.

In the experimental class, the students did not know and understood the concept of Kepler's Law learning material. These results can be seen in the works of low pretest scores. Most students do not understand and know Kepler's Law and understand other concepts. When carrying out learning activities, to be precise, at the meeting, the two students made a line of eccentricity with each group that had been previously formed. In addition to making the line of abnormality, students also understand Kepler's Law concepts. This activity makes students begin to understand some of the ideas of learning material. The post-test results showed that the HOTS differences among students increased more than the previous pretest results. This condition proves that students begin to understand and know Kepler's Law's concepts and sounds even though the increase is not too significant.

Based on pretest number 1 that measures the level of students' high-order thinking skills related to Kepler's Law, it was found that two new students knew a very general picture of Kepler's Law. The very available description in question is the discoverer's name and Kepler's Laws' main content relating to the solar system. Two students (student A and student B) don't even understand Kepler's Law at all. Student A and student B's understanding of Kepler's Law has not changed much. After following the post-test, it appears that they know the very general description of Kepler's Law. They know who discovered it but cannot explain the history of the invention and the concept.

After following the post-test, it appears that an understanding of the

history of Kepler's Law has developed. Students know the discoverer of Kepler's Law and the history of its discovery. However, an understanding of the history of Kepler's Law's discovery is still incomplete because it does not explain that Kepler's Law reinforces the shift in the concept of geocentric to heliocentric. Regarding the idea of Kepler's Law, students can already explain Laws I and III. The explanation given regarding Kepler's First Law is that orbitals are elliptical. This understanding is incomplete because the student does not mention the center of the orbital. Students also explain Kepler's Third Law with its mathematical equations but do not explain what is governed by these equations.

Another student, namely student C, understands Kepler's Law better than the pretest. He knows the founder of this law. His understanding of the history of Kepler's Law's discovery is also more complete because he understands that the background for the formulation of Kepler's Law is discovering the orbital eccentricity value of Mars. Like the other students, he did not explain that Kepler's Law confirmed the shift in the concept of geocentric to heliocentric. However, student D understands the idea of Kepler's Law I and III completely. He wrote mathematical equations and what is governed by Kepler's Law III

equations. He also understands the concept of Kepler's Second Law, but there is a wrong explanation, namely, saying the sun exerts a magnetic force.

At the pretest stage, students did not understand the relationship between the radius of the planet's orbit and the period of the planet's revolution. Students become confused when faced with a mathematical problem that requires them to calculate the planet's orbit's radius through data on the process and the other two planets' orbital radius. Students do not understand Kepler's Third Law because students must first understand the concept of the orbital period and its difference with the total orbital time. Also, students need to understand the concept of orbital radius and its contrast with the satellite's height or position from the Earth's surface.

The next meeting of learning activities in the control class is carried out online using chat groups via WhatsApp, this activity is carried out because it is a requirement of the Blended Learning learning model, in that group students are given the freedom to discuss and exchange ideas about the learning material being discussed so that students are more active in following This online discussion activity, after conducting online discussions the control class students were also given a post-test, the post-test results also showed that the

difference in student achievement was more increased than the previous pretest results as evidenced by the lowest score in the post-test results based on table 4 of 20 which shows a more significant number from the lowest value on the pretest results while for the highest score on the post-test results, namely 55,This condition proves that students begin to understand and know the concepts and sounds of Kepler's Law even though the increase is not too significant, but students are able to achieve the pass threshold value for this Kepler Law material, not only based on post-test results, HOTS achievement of control class students is also seen from the effects of several activities. Questions on Student Worksheets that have been given.

One of the factors causing the low student HOTS is the adaptation to mental readiness conditions that must fill learning activities during the Covid-19 pandemic. Therefore students cannot be actively involved and only become listeners when carrying out learning activities.

The results of the Hypothesis using the Maan Whitney test in table 5 show a significance value <0.05, which proves that the Hypothesis H_1 of this study is accepted. Namely, using STEM-blended learning can help students achieve HOTS (High-Order Thinking Skills). The implementation of learning in both classes includes the excellent category, although not too significant, based on the Blended Learning model's syntax.

The N-gain assessment in Table 6 shows the difference in achievement improvement. The experimental class is included in the medium category, and the control class is included in the low sort. These results prove that STEM-blended learning can improve students' HOTS abilities. Learning activities through the experimental grade have a significant influence on the HOTS results from students.

The results of other studies also show that Students who discovered thru inquiry-primarily based totally STEM mastering can grow their essential wondering to satisfy the criterion (Onsee and Nuangchalerm, 2019). Through the layout of STEM coaching it's going to fill gaps in know-how the idea of evolution and its importance for the lives of many organisms and for instructors to look evolution from a completely broad, bendy and interdisciplinary perspective (Aberilla *et al.*, 2021). Therefore, STEM schooling desires to be promoted in particular in hassle fixing and designing sports to aid high quality perceptions (Sulaeman *et al.*, 2020).

The results show that there has been a dynamic of learning as part of the education segment during the Covid-19

pandemic by ignoring the phenomena summarized through observation, interviews, and document studies related to the implementation of blended learning-based learning at the school level. The education system's performance has transformed various activity lines, including learning activities that are entirely forced to take place online. This study confirms that every element involved in learning activities is unprepared for spontaneous changes during the Covid-19 pandemic.

Implementing the learning system in education units has undergone a generalized change in operational form through learning policies and following social guidelines, namely social distancing instructions that lead to calls for lockdowns. The public response to this policy varied widely, initially limited to sensitization conditions. This condition can make each more responsive to certain aspects of the environment. This aspect is the change that is brought about by these social restrictions.

Social distance restricts space and time for all normal learning system tasks at every level of schooling. Learning generally takes place in classes with a certain timetable, which in each room is converted into knowledge, with time not realistic as set forth in the schedule. This is the result of the call for social

limitations, which in turn restricts education. The phrase mixed learning is better known and commonly done in the past. This situation is better than others. It is incorporated into STEM-mixed learning as an alternative among various more effective kinds of information. The results of other studies show that essential structural version of teachers' competence to broaden expert competence approximately incorporated STEM schooling and a few orientation for constructing the shape of the expert improvement program (Thuy, Bien and Quy, 2020).

STEM-blended learning is an option in conditions to prevent the spread of Covid 19 and gives a unique color to the period of struggle against this virus. Even this form of STEM-blended learning can be interpreted as maintaining access to education. Education that generally occurs with direct interaction between elements (educators and education personnel and students) turns into indirect interaction learning. Restrictions on direct interactions in education sometimes happen in certain situations but not in the context of social conditions such as those that people live in to prevent the spread of the virus. This limitation has a positive and negative impact on the achievement of learning objectives. Social restrictions affect the implementation of education

policies, and learning must be endeavored to continue with various consequences. This is very influential during the adaptation period due to changes in the learning mechanism and system. This is in line with other studies that integrating STEM training in particular the engineering element in an optionally available technological know-how magnificence is precious for college students to acquire crucial talents for his or her destiny consisting of layout and collaboration (Sulaeman *et al.*, 2021). The implementation of STEM schooling may be a cause for renewal withinside the global of schooling (Farwati *et al.*, 2021).

Firstly, the beneficial influence may be evaluated by learning from home from the situation of educators who perform academic work (LFH). In order to maximize technology and information, LFH makes each student who carries out their activities more independent. Earlier, not all pupils used to work with IT, but they were made more acclimated and qualified by these conditions in completing their IT activities. Why not? Educational practitioners are faced with situations that compel and require them to become proficient instantly. This social distancing moment has increased creativity and competence in carrying out each task through STEM-blended learning.

CONCLUSION

The students' higher-order thinking skills for the experimental class was included in the medium category with a percentage of achievement of 75%. However, in the control class, it was included in the medium category with a rate of 61%. The results showed that there were significant differences between experimental and control classes with the value .0015 < 0.05, meaning that the implementation of STEM-Blended learning is effective to enhance high school students' high-level thinking skills on Kepler law concept.

SUGGESTIONS

These findings will be usefull for the development of STEM Education during Covid-19 outbreak. After carrying out the research and some shortcomings during the implementation of learning, the researcher suggests some suggestions for further research to make it better, namely as follows: (1) ensure that the place to be studied has facilities and does not have limitations to access the internet so that when carrying out online learning do not feel difficulties or confusion because of the presence of students, (2) understand and explore the learning indicators that

will be carried out and carry out learning activities following the learning objectives, (3) understand and deepen learning material both the concept of learning materials and formulas in the learning material will be implemented,(4) increasing creativity when they want or will use learning media so that students have an interest in learning and also so that students better understand the learning material.

REFERENCES

Abdurrahman 2019a, 'Design and validation of inquiry-based STEM learning strategy as a powerful alternative solution to facilitate gifted students facing 21st century challenging', *Journal for the Education of Gifted Young Scientists*, vol. 7, no. 1, pp. 33–56. doi: 10.17478/jegys.513308.

Abdurrahman 2019b, 'Designing an Inquiry-based STEM Learning strategy as a Powerful Alternative Solution to Enhance Students' 21st-century Skills: A Preliminary Research', *Journal of Physics: Conference Series*. doi: 10.1088/1742-6596/1155/1/012087.

Aberilla, O. D. *et al* 2021, 'University Students' Accepta nce of Evolution: Basis for STEM-based Instructional Design', *International Journal of STEM Education for Sustainability*, vol.1, no. 1, pp. 33–44.

Aguilar-Rodríguez, M 2019, 'A blended-learning programme regarding professional ethics in physiotherapy students', *Nursing Ethics*, vol. 26, no. 5, pp. 1410–23. doi: 10.1177/0969733017748479.

Akhsan, H 2020, 'Development of HOTS (higher order thinking skills) test instruments for the concept of fluid and harmonic vibrations for high schools', *Journal of Physics: Conference Series*. doi: 10.1088/1742-6596/1480/1/012071.

Amir, L. R 2020 'Student perspective of classroom and distance learning during COVID-19 pandemic in the undergraduate dental study program Universitas Indonesia', *BMC Medical Education*, vol. 20, no. 1. doi: 10.1186/s12909-020-02312-0.

Arai, F 2020, 'Machine Learning of Hematopoietic Stem Cell Divisions from Paired Daughter Cell Expression Profiles Reveals Effects of Aging on Self-Renewal', *Cell Systems*, vol. 11, no. 6, pp. 640–52. doi: 10.1016/j.cels.2020.11.004.

Awang, Z. *et al* 2020, 'Exploring steam teaching in preschool using fred rogers approach', *International Journal of Evaluation and Research in Education*, vol. 9, no. 4, pp. 1071–78. doi: 10.11591/ijere.v9i4.20674.

Carroll, K. A 2020, 'Using a Repetitive Instructional Intervention to Improve Students' Higher-Order Thinking Skills', *College Teaching*. doi: 10.1080/87567555.2020.1823310.

Chen, X., Breslow, L. and DeBoer, J 2018, 'Analyzing productive learning behaviors for students using immediate corrective feedback in a blended learning environment', *Computers and Education*, 117(September 2017), pp. 59–74. doi: 10.1016/j.compedu.2017.09.013.

Creswell, J. W 2013, 'Research Design Qualitative, Quantitative, and Mixed Method Approaches', p. 273.

Dewi, R. M 2020, 'High order thinking skills instrument on microeconomics course: A development research', *International Journal of Instruction*, vol. 13, no. 4, pp. 283–94. doi: 10.29333/iji.2020.13418a.

Eaton, A 2018, 'A blended learning curriculum for training peer researchers to conduct community-based participatory research', *Action Learning: Research and Practice*, vol. 15, no.2, pp. 139–50. doi: 10.1080/14767333.2018.1462143.

Etika, E. D 2020 'Meta-Analysis: Google classroom on mathematics learning in Indonesia as an alternative online media during the COVID-19 pandemic', *Journal of Physics: Conference Series*. doi: 10.1088/1742-6596/1663/1/012045.

Farwati, R. *et al.* (2021) 'STEM Education Implementation in Indonesia: A Scoping Review', *International Journal of STEM Education for Sustainability*, vol. 1, no. 1, pp. 11–32.

Ghazal, S 2018, '"i am Still Learning": Modeling LMS Critical Success Factors for Promoting Students' Experience and Satisfaction in a Blended Learning Environment', *IEEE Access*, 6, pp. 77179–201. doi: 10.1109/ACCESS.2018.2879677.

Green, R. A 2018, 'The relationship between student engagement with online content and achievement in a blended learning anatomy course', *Anatomical Sciences Education*, vol. 11, no. 5, pp. 471–
477. doi: 10.1002/ase.1761.

Hake, R. R 1998, 'Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses', *American Journal of Physics*, vol. 66, no. 1, pp. 64–74. doi: 10.1119/1.18809.

Haryadi, R. and Pujiastuti, H 2020, 'Use of bungee jumping with stem approach to improve science process skills', *Journal of Physics: Conf. Series*. doi: 10.1088/1742-6596/1480/1/012073.

Hidayati, D 2020, 'Implementation of online learning during the covid-19 epidemic in Indonesia: Assessment of higher education students' use and implementation of online learning technology', *Universal Journal of Educational Research*, vol. 8, no. 10, pp. 4514-19. doi: 10.13189/ujer.2020.081019.

Hong, H 2019, 'Integrated STEM Learning in an Idea-centered Knowledge-building Environment', *Asia-Pacific Education Researcher*, vol. 28, no.1, pp. 63–76. doi: 10.1007/s40299-018-0409-y.

Huang, L 2020, 'Deep reinforcement learning for online computation offloading in wireless powered mobile-edge computing networks', *IEEE Transactions on Mobile Computing*, 19(11), pp. 2581–2593. doi: 10.1109/TMC.2019.2928811.

El Islami, R. A. Z. and Nuangchalerm, P 2020, 'Comparative study of scientific literacy: Indonesian and thai pre-service science teachers report', *International Journal of Evaluation and Research in Education*, vol. 9, no. 2, pp. 261–

68. doi: 10.11591/ijere.v9i2.20355.

Kranzfelder, P 2019, 'Instructional practices in reformed undergraduate STEM learning environments: a study of instructor and student behaviors in biology courses', *International Journal of Science Education*, vol. 41, no. 14, pp. 1944–61. doi: 10.1080/09500693.2019.1649503.

Kusumawati, A. J 2020, 'Redesigning face-to-face into online learning for speaking competence during covid-19: Esp for higher education in Indonesia', *International Journal of Language Education*, vol. 4, no.2, pp. 276–88. doi: 10.26858/ijole.v4i2.14745.

Lazarinis, F 2019, 'A blended learning course for playfully teaching programming concepts to school teachers', *Education and Information Technologies*, vol.24, no.2, pp. 1237–49. doi: 10.1007/s10639-018-9823-2.

Leite, F 2018, 'A Blended Learning Method Applied in Data Communication and Computer Networks Subject', *IEEE Latin America Transactions*, vol.16, no.1, pp. 163–71. doi: 10.1109/TLA.2018.8291469.

Magas, C. P. *et al* 2017, 'Intraoperative questioning to advance higher-order thinking', *American Journal of Surgery*, vol. 213, no. 2, pp. 222–226. doi: 10.1016/j.amjsurg.2016.08.027.

Mailizar 2020, 'Secondary school mathematics teachers' views on e-learning implementation barriers during the COVID-19 pandemic: The case of Indonesia', *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 16, no. 7, doi: 10.29333/EJMSTE/8240.

Mawardi, M 2020, 'Effectiveness of student worksheets based guided inquiry on acid base material to improve students higher order thinking skill (HOTS)', *Journal of Physics: Conference Series*. doi: 10.1088/1742-6596/1481/1/012083.

McCutcheon, K 2018, 'Online learning versus blended learning of clinical supervisee skills with pre-registration nursing students: A randomised controlled trial', *International Journal of Nursing Studies*, vol. 82, pp. 30–39. doi: 10.1016/j.ijnurstu.2018.02.005.

Mohd Najib, S. A., Mahat, H. and Baharudin, N. H 2020, 'The level of STEM knowledge, skills, and values among the students of bachelor's degree of education in geography', *International Journal of Evaluation and Research in Education*, vol. 9, no.1, pp. 69–76. doi: 10.11591/ijere.v9i1.20416.

Mulyanti, B 2020, 'Distance learning in vocational high schools during the covid-19 pandemic in West Java province, Indonesia', *Indonesian Journal of Science and Technology*, vol. 5, no.2, pp. 271–82. doi: 10.17509/ijost.v5i2.24640.

Muthmainnah 2019, 'Constructing Reasoning Multiple Choice Test to Measure Bloomian Higher Order Thinking Skills in Physics of XI Grade Students', *Journal of Physics: Conference Series*. doi: 10.1088/1742-6596/1233/1/012037.

Ng, C 2018, 'Integrating STEM education through Project-Based Inquiry Learning (PIL) in topic space among year one pupils', *IOP Conference Series: Materials*

Science and Engineering. doi: 10.1088/1757-899X/296/1/012020.

Ngan, L. H. M. *et al* 2020, 'Exploring Vietnamese Students' Participation and Perceptions of Science Classroom Environment in STEM Education Context', *Jurnal Penelitian dan Pembelajaran IPA*, vol. 6, no.1, p. 73. doi: 10.30870/jppi.v6i1.6429.

Nisa, K 2020, 'The COVID-19 impact on statistical learning at State Islamic University in East Indonesia', *Journal of Physics: Conference Series.* doi: 10.1088/1742-6596/1663/1/012051.

Nugent, G 2019, 'Wearable Textiles to Support Student STEM Learning and Attitudes', *Journal of Science Education and Technology*, 28(5), pp. 470–79. doi: 10.1007/s10956-019-09779-7.

Onsee, P. and Nuangchalerm, P 2019, 'Developing Critical Thinking of Grade 10 Students through Inquiry-Based STEM Learning', *Jurnal Penelitian dan Pembelajaran IPA*, vol.5, no.2, p. 132. doi: 10.30870/jppi.v5i2.5486.

Parno 2020, 'A case study on comparison of high school students' scientific literacy competencies domain in physics with different methods: PBL-stem education, PBL, and conventional learning', *Jurnal Pendidikan IPA Indonesia*, vol.9, no.2, pp. 159–68. doi: 10.15294/jpii.v9i2.23894.

Philipsen, B 2019, 'Improving teacher professional development for online and blended learning: a systematic meta-aggregative review', *Educational Technology Research and Development*, vol.67, no.5, pp. 1145–74. doi: 10.1007/s11423-019-09645-8.

Pool, G. and Byatt, A. S 1996, 'Chronicle of Higher Education', *The Women's Review of Books*, 13(10/11), p. 35. doi: 10.2307/4022491.

Popovic, N 2018, 'A Moodle-based blended learning solution for physiology education in Montenegro: A case study', *Advances in Physiology Education*, vol. 42, no. 1, pp. 111–117. doi: 10.1152/ADVAN.00155.2017.

Pujiastuti, H. and Haryadi, R 2020, 'The Use of Augmented Reality Blended Learning for Improving Understanding of Food Security', *Jurnal Pendidikan IPA Indonesia*, vol. 9. no.1, pp. 59–69.

Putri, R. S 2020, 'Impact of the COVID-19 pandemic on online home learning: An explorative study of primary schools in Indonesia', *International Journal of Advanced Science and Technology*, 29(5), pp. 4809–18. Available at: https://www.scopus.com/inward/record.uri?partnerID=HzOxMe3b&scp=85084477638&origin=inward.

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*, vol.19, no.6, pp. 1–26. doi: 10.26803/ijlter.19.6.1.

Rasheed, R 2020, 'Challenges in the online component of blended learning: A systematic review', *Computers and Education*, 144. doi: 10.1016/j.compedu.2019.103701.

Rasmitadila 2020, 'The perceptions of primary school teachers of online learning during the covid-19

pandemic period: A case study in Indonesia', *Journal of Ethnic and Cultural Studies*, vol. 7, no. 2, pp. 90–109. doi: 10.29333/ejecs/388.

Saritepeci, M 2019, 'Developing Computational Thinking Skills of High School Students : Design-Based Learning Activities and Programming Tasks', *The Asia-Pacific Education Researcher*. doi: 10.1007/s40299-019-00480-2.

Saw, G. K. *et al* 2019, 'Out-of-school time STEM program: Students' attitudes toward and career interests in mathematics and science', *International Journal of Evaluation and Research in Education*, vol. 8, no.2, pp. 356–62. doi: 10.11591/ijere.v8i2.18702.

Shu, H 2018, 'Determining the differences between online and face-to-face student–group interactions in a blended learning course', *Internet and Higher Education*, 39, pp. 13–21. doi: 10.1016/j.iheduc.2018.05.003.

Singh, C. K. S 2020, 'A review of research on the importance of higher order thinking skills (HOTS) in teaching english language', *BMC Veterinary Research*, vol.7, no.8, pp. 740–47. doi: 10.31838/jcr.07.08.161.

Sinta, B 2020, 'Designing creative problem solving-based student worksheet for higher order thinking skills', *Journal of Physics: Conference Series*. doi: 10.1088/1742-6596/1480/1/012045.

Siripongdee, K 2020, 'A blended learning model with IoT-based technology: Effectively used when the COVID-19 pandemic?', *Journal for the Education of Gifted Young Scientists*, 8(2), pp. 905–917. doi: 10.17478/JEGYS.698869.

Siron, Y 2020, 'Factors Affecting The Adoption Of E-Learning In Indonesia: Lesson From Covid-19', *Journal of Technology and Science Education*, vol.10, no.2, p. 282. doi: 10.3926/jotse.1025.

Stites, N. A 2019, 'A cluster-based approach to understanding students' resource-usage patterns in an active, blended, and collaborative learning environment', *International Journal of Engineering Education*, vol. 35, no.6, pp. 1738–57.

Sulaeman, N. F. *et al* 2020, 'Engaging STEM Education for High School Student in Japan: Exploration of Perception to Engineer Profession', *Jurnal Penelitian dan Pembelajaran IPA*, vol. 6, no. 2, p. 194. doi: 10.30870/jppi.v6i2.8449.

Sulaeman, N. F. *et al* 2021, 'Exploring Student Engagement in STEM Education through the Engineering Design Process', *Jurnal Penelitian dan Pembelajaran IPA*, vol. 7. no.1, p. 1. doi: 10.30870/jppi.v7i1.10455.

Sumarni, W. *et al* 2020, 'The urgency of religious and cultural science in stem education: A meta data analysis', *International Journal of Evaluation and Research in Education*, vol. 9, no. 4, pp. 1045–54. doi: 10.11591/ijere.v9i4.20462.

Sun, L. 2020, 'STEM learning attitude predicts computational thinking skills among primary school students', *Journal of Computer Assisted Learning*. doi: 10.1111/jcal.12493.

Taufik, H 2020, 'Motivation and Skills of

Science Teachers' Online Teaching through Online Learning Training in the Covid-19 Period in Pekanbaru Indonesia', *Journal of Physics: Conference Series*. doi: 10.1088/1742-6596/1655/1/012064.

Thuy, N. T. T., Bien, N. Van and Quy, D. X 2020, 'Fostering Teachers' Competence of the Integrated STEM Education', *Jurnal Penelitian dan Pembelajaran IPA*, vol.6, no.2, p. 166. doi: 10.30870/jppi.v6i2.6441.

Tikadar, S 2018, 'A blended learning platform to improve teaching-learning experience', *Proceedings - IEEE 18th International Conference on Advanced Learning Technologies, ICALT 2018*, pp. 87–89. doi: 10.1109/ICALT.2018.00027.

Wahidah (2020) 'High Order Thinking Skill (HOTS) Principles in Developing Students Worksheet', *Asian EFL Journal*, vol.27, no.43, pp. 5–16.

Wang, Q 2018, 'Pedagogical, social and technical designs of a blended synchronous learning environment', *British Journal of Educational Technology*, vol. 49, no.3, pp. 451–62. doi: 10.1111/bjet.12558.

West, R. E. *et al* 2017, '"Picturing Them Right in Front of Me": Guidelines for Implementing Video Communication in Online and Blended Learning', *TechTrends*, vol. 61, no.5, pp. 461–69. doi: 10.1007/s11528-017-0208-y.

Wiseman, D 2020, 'Whole-some Artifacts: (STEM) Teaching and Learning Emerging from and Contributing to Community', *Canadian Journal of Science, Mathematics and Technology Education*, vol.20, no.2, pp. 264–80. doi: 10.1007/s42330-020-00079-6.

Zhao, J 2020, 'Learning in the Field: Comparison of Desktop, Immersive Virtual Reality, and Actual Field Trips for Place-Based STEM Education', *Proceedings - 2020 IEEE Conference on Virtual Reality and 3D User Interfaces, VR 2020*, pp. 893–902. doi: 10.1109/VR46266.2020.1581091 793502.

Zydney, J 2019, 'Here or There Instruction: Lessons Learned in Implementing Innovative Approaches to Blended Synchronous Learning', *TechTrends*, vol. 63, no. 2, pp. 123–132. doi: 10.1007/s11528-018-0344-z.

Zydney, J 2020, 'Learning through experience: Using design based research to redesign protocols for blended synchronous learning environments', *Computers and Education*, 143. doi: 10.1016/j.compedu.2019.103678.