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# PHET and PBL: Do They Work Well Together in Improving Mathematical Critical Thinking and Problem Solving Ability?

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**Abstract: PHET and PBL: Do They Work Well Together in Improving Mathematical Critical Thinking and Problem Solving Ability?. Objectives:** This research aims to examine the effectiveness of the use of PBL combined with PHET rather than PBL about mathematical critical thinking and problem-solving ability. **Methods:** This research employed an experimental approach involved a sample of 63 students of grade VIII's favorite *MTs* in Sidoarjo Regency, East Java, divided into 2 classes (PBL class combined with PHET and regular PBL class). The data were analyzed with descriptive statistics combined with Mann-Whitney's statistical test. **Findings:** This research finds out that there is no difference in the influence of the intervention on the application of PBL combined with PHET with the usual PBL group in developing students' mathematical problem-solving ability, and there are differences in the influence of interventions on the implementation of PHET integrated PBL and the application of ordinary PBL in developing students' mathematical critical thinking ability. **Conclusion:** Based on findings, the importance of providing adequate computer facilities for students when they want to implement website-based learning media such as PHET.

**Keywords:** PHET**,** PBL, problem solving, critical thinking, and mathematics.

***Abstrak: PHET dan PBL: Apakah Mereka Bekerjasama dengan Baik dalam Meningkatkan Kemampuan Berpikir Kritis Matematis dan Pemecahan Masalah? Objectives:*** *Penelitian ini bertujuan menguji efektivitas penggunaan PBL dipadu PHET dibandingkan PBL dalam kaitan kemampuan problem solving dan berpikir kritis matematis.* ***Metode:*** *Penlitian dengan pendekatan eksperimen melibatkan sampel sebanyak 63 siswa kelas VIII MTs favorit di Kabupaten Sidoarjo Jawa Timur, terbagi dalam 2 kelas (Kelas PBL dipadu PHET dan kelas PBL biasa)). Data dianalisis dengan statistik deskriptif yang dipadu dengan uji statistik Mann Whitney.* ***Hasil:*** *Temuan penelitian ini di antaranya tidak ada perbedaan pengaruh intervensi pada penerapan PBL dipadu PHET dengan kelompok PBL biasa dalam mengembangkan kemampuan pemecahan masalah matematika siswa, dan terdapat perbedaan pengaruh intervensi pada penerapan PBL diintegrasikan PHET dan penerapan PBL biasa dalam mengembangkan kemampuan berpikir kritis matematis siswa.* ***Conclusion:*** *perlunya menyediakan sarana komputer yang memadai bagi siswa ketika hendak mengimplementasikan PBL dipadu media pembelajaran berbasis website seperti PHET.*

***Kata kunci:*** *PHET**,** PBL, pemecahan masalah, berpikir kritis, dan matematika.*

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## INTRODUCTION

In the era of society 5.0, the world of education is required to carry out various innovations such as the encouragement of computer use and learning reforms to create superior students' skills (Alvarez-Cedillo et al., 2019; Shiroishi et al., 2018). In this era, the characterized by learning that is directly connected digital technology systems (Nusantara, Zulkardi & Putri, 2021; Özdemir & Hekim, 2018). This digital system is very important when there is a Covid-19 pandemic since the beginning of 2020, where teachers are forced to teach remotely or online (Furenes, Kucirkova, & Bus, 2021; Rasmitadila et al., 2020).

The same condition is experienced by students (Bakker, Cai, & Zenger, 2021; Juarez & Critchfield, 2021). They are faced with a learning process that makes it difficult the development of their thinking skills (Bisht, Jasola, & Bisht, 2020; Rahman, Zukarnain, Zain, & Yusof, 2021; Richmond, Cho, Gallagher, He, & Petchauer, 2020). Research conducted by Garad et al., (2021) it shows that limited communication and interaction are one of the causes of the difficulty of developing students' critical thinking skills in Indonesia. The same case also occurs in other countries such as in Malaysia (Mahmud & German, 2021), China (Feng et al., 2021), Amerika Serikat (Mellieon & Robinson, 2021), also Swiss (Müller & Mildenberger, 2021).

In fact, critical thinking is very necessary to analyze and synthesize various kinds of information faced by students in their daily lives (Atabaki, Keshtiaray & Yarmohammadian, 2015). The ability to think critically that is balanced with the emphasis of the use of logic is what will create a mathematical mindset (Saragih & Napitupulu, 2015). In contrast, the ability to think critically can also be formed and developed through mathematics. This description confirms to us that the ability to think critically and mathematically has a very strong mutualistic symbiosis, so it can be elaborated into the ability to mathematical critical thinking. This mathematical critical thinking ability is very important for students because with these skills students are able to be rational and choose the best alternative option for themselves. This ability is needed when looking for solutions to the problems they face in everyday (Kusaeri, Lailiyah, Arrifadah & Asmiyah, 2022).

When the pandemic hit Indonesia since 2020, online learning that was carried out greatly affected the development of students' mathematical critical thinking ability (Goodsett, 2020; Lestari et al., 2021). Another mathematical ability affected is the ability of problem solving (Adedoyin & Soykan, 2020; Henry, 2021; Holloway et al., 2021; Hung & Sitthiworachart, 2020 and Yudiawan et al. 2021). Looking at the series of research results above, it turns out that the problem is experienced by many countries. The ability to think mathematically critical thinking and problem solving is very important to note, because it is very helpful for students to make creative solutions to the mathematical problems they face (Davis et al., 2019; Huang et al. 2020; Son & Fatimah, 2020; Wechsler et al. 2018, Yanti, Kusaeri, & Kustianingsih, 2020).

Poor handling of the problem could lead to a decrease in the quality of education (Sarwanto et al., 2021). Research conducted by Vandenhouten et al. (2017) and Tawfik et al. (2021) find that the application of real-world problems in the classroom is an effective strategy for developing students' mathematical critical thinking and problem solving skills. One learning model that involves students in problem solving in the real world is Problem Based Learning (PBL). Through PBL, the ability to think mathematically critical thinking and problem solving become better (Kusaeri & Sholeh, 2017; Sianturi et al., 2018; Suparman et al., 2021).

Various researchers have tried to implement PBL to develop students' mathematical critical thinking skills in problem solving frames, as is done by Manurung & Panggabean (2020) Ranjanie & Rajeswari (2016) Engen et al., (2018), Malan et al., (2014), Ungaretti et al., (2015), and Virtue & Hinnant-Crawford, (2019).

The implementation of PBL combined with innovative learning media when online learning is effective, almost close to face-to-face learning (Richmond et al., 2020). Research conducted by Al-samarraie (2019), Ayega (2020) and Yustina et al. (2020) found that the mathematical learning media combined with PBL is considered very effective in improving mathematical critical thinking and problem solving abilty when the limitations of face-to-face time such as during this pandemic. This is because learning becomes interactive, so making abstract mathematical materials will be easier for students to understand (Sangsawang, 2020).

However, not all technology-based learning media can be combined with PBL. Basilotta Gómez-Pablos et al. (2017) and Noverati et al. (2020) mentioned that the media that is used as a support for PBL must be able to create an atmosphere related to real life. The same is expressed by Rahmawati et al. (2020) that collaborative, cooperative and constructive media can make it easier for students to learn highly relevant material with PBL. Learning media that meet the above characteristics are website-based media such as Play mathmatics with Technology or PHET (Duncan, Smith, & Cook, 2013; Hursen, 2021). PHET media is a website-based learning medium that adopts Physics Education Technology (PHET). PHET carries a modern per-toy and can be played independently by students, that contains simulations by converting abstract mathematical concepts into materials closer to real-lift support math learning in the classroom (Engelbrecht, Linares, & Borba, 2020; Tang, Chang, & Hwang, 2021). PHET can be used as a real laboratory-based multi-media learning reference for mathematics (Serungke, Muhibbuddin & Suhrawardi, 2020). That is, PHET becomes ventilation to support the mathematical learning process to make it more interesting.

The combination of PBL with PHET media can be done because there is a wedge between both of PBL with PHET. PBL is learning that begins with a problem (Chin & Chia, 2004; Judge et al., 2011), meanwhile, PHET contains the problem section and contains problems that students must solve during the learning process (Noetel et al., 2021). Research related to the implementation of PHET media combined with PBL about improving the mathematical critical thinking and problem solving ability has been conducted by several researchers. For example, research conducted by Rahmawati et al. (2020), Remillard et al., (2021) and Rezat (2021). In general, the researchers concluded that PBL, which is collaborated with learning media that are presented visually and interactively to students, will be more easily accepted by students in digesting learning materials.

The results of the research and the opinions of the experts that have been discussed indicate the importance of using PHET media combined with PBL in relation to the improvement of mathematical critical thinking and problem solving ability. However, the studies that have been mentioned above are done when the mathematical learning process takes place normally. Research that seeks to focus on the application of PBL combined with PHET at a time when the transition from online learning back to face-to-face learning or the transition from online to face-to-face is limited has not been found. This is an interesting gap to research and will be worked on through this research. PHET itself is specially designed to carry a modern game system and can be

played independently by students. The appearance of new concepts and close to real life is expected to construct mathematical critical thinking skills and eventually trigger the emergence of pro-blem solving creative abilities of students who are almost said to be clogged during the pandemic.

## METHODS

This research was conducted in one of the favorite State *MTs* in Sidoarjo-East Java Regency in August – September 2021. This madrasah was chosen because they represented their favorite MTs in Sidoarjo Regency, so that the potential for students' abilities spread from less to higher (with a tendency to be more capable). These considerations become important, because to bring up the ability to think critically mathematically and problem solving needed children who are struggling and above. Another consideration, this madrasah has implemented a full face-to-face learning policy (during the pandemic) with strict health protocols. With face-to-face learning, learning management with PHET media is more effective and easier than online learning patterns. Because, PHET is a learning media in the form of modern games that carry contextual themes with Islamic nuances and can be accessed on the website *http://phet-uinsa.com/.*

### Sample

The research sample as many as 63 students of grade VIII (82.54% female and 17.46 male) in the odd semester 2021/2022 were taken by purposive sampling techniques. These students are in the favorite class (Class VIII-A and VIII-B) from 6 classes in MTs that have equivalent abilities. The selection of favorite classes with the intention that mathematical critical thinking and problem solving abilty can be explored properly. The "Number Patterns" material was chosen based on an initial survey conducted pre-research through google form of 25 *MTs*/junior high school mathematics teachers in Sidoarjo Regency and Surabaya City. The results were obtained three materials that became the anxiety of the teachers: algebraic form calculation operations, number patterns and quadratic functions. However, it turns out that the number pattern material has the characteristics closest to the PHET medium. Of the 63 students, they are divided into two groups: Group-1 (Class of VIII-A as the PBL group that PHET is inducted) and Group-2 (Class of VIII-B as the PBL group).

### Data Collection Techniques

To assess the competency of mathematics critical thinking and problem solving, a three-item essay exam was employed, adapted from the Indonesian Madrasah Competency Assessment (AKMI) of the Ministry of Religious Affairs of the Republic of Indonesia (Appendix). The three test items are arranged based on mathematical critical thinking indicators and problem solving indicators. The mathematical critical thinking indicator used refers to Watson & Glaser (2002) namely (i) inference, (ii) recognition of assumption, (iii) deduction, (iv) interpretation, and (v) evaluation of arguments. Meanwhile, problem solving indicators trace to krulik & rudnick theory (1989) which includes: (i) read and think, (ii) explore and plan, (iii) select a strategy, (iv) find an answer and (v) reflect and extend.

Furthermore, validation was carried out on the three items to find out whether the test form of the description developed has been representative of the ability to think critically mathematically and problem solving. The results of the analysis showed that the three items developed had a difficulty level with an average of 0.324. This implies that the exam items have a high difficulty index and are appropriate for assessing mathematical critical thinking and problem solving skills. Meanwhile, the validity of

the instrument obtained a value of 0.778 (minimum = 0.667, maximum = 0.917) is calculated using the Aiken V formula. Furthermore, this is evidence that the test instrument is valid for the interpretation of the score. That is, high mathematical critical thinking scores and problem solving actually reflect high student abilities as well, while low scores reflect low student abilities.

**Data Analysis**

Descriptive statistical analysis (mean, standard deviation, skewness, kurtosis and percentage) combined with non parametric statistical tests (in this case the Mann Whitney test) was conducted to answer the purpose of this research. The analysis was carried out with the help of statistical package for social science (SPSS) version 24. Overall, the signifi-kansi level used at the p value is 0.05.

## RESULT AND DISCUSSIONS

The data obtained in this research is a score of mathematical critical thinking skills and problem solving between the PBL class integrated by PHET and the PBL class only. A description of the characteristics of students in both groups is presented in Table 1. In addition to mean and SD, Table 1 also presented skewness and kurtosis information to see the normality and homogeneity of data used as a prerequisite for the F-test. From Table 1 obtained skewness and kurtosis values beyond the interval of -1.96 to 1.96. This indicates that the data used is not homogeneous and also does not distribute normally (Hoyle, 1995).

**Table 1.** Characteristics of PBL group students combined with PHET with PBL group only

| | N | Mean | SD | Min | Max | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| **PBL Combined PHET** | | | | | | | |
| *Problem Solving* | 30 | 10.018 | 2.315 | 0.00 | 9.00 | -0.127 | 0.002 |
| Critical Thinking Mathematically | 30 | 6.595 | 2.325 | 0.00 | 9.00 | 2.921 | 2.105 |
| **PBL** | | | | | | | |
| *Problem Solving* | 33 | 9.331 | 3.657 | 0.00 | 13.00 | -0,004 | -1.991 |
| Critical Thinking | 33 | 8.331 | 3.218 | 0.00 | 10.00 | 1,434 | -1.435 |

Neither homogeneous nor normal distribution of the data, encouraging the need for non-parametric statistical tests, in this case the Mann-Whitney test. Mann-Whitney is one of the non-parametric statistical test techniques for determining the difference between two independent groups that are not normally distributed (Navarro, Aleman, Sandoval, Matamala & Corsini, 2020). The results are presented as in Table 2 and show the significance of the problem solving ability of *MTs* level students of 0.068 ($p>0.05$).

That is, there is no difference in influence between the PBL group combined with PHET with the usual PBL group in developing the problem solving ability of *MTs* students. Conversely, in the aspect of critical thinking ability, the test results showed a significance level of 0.029 ($p<0.05$). This figure gives the meaning that there are differences in the influence of interventions on the implementation of PHET integrated PBL as well as the application of PBL to develop the mathematical critical thinking capabilities of *MTs* students.

**Table 2.** Mann-whitney test of PBL implementation integrated PHET and regular PBL

| Ability | Mann-Whitney | Z | Asymp. Sig. (2-tailed) |
|---|---|---|---|
| Critical Thinking | 46.500 | -2.179 | .029 |
| *Problem Solving* | 53.000 | -1.865 | .068 |

To explore in more detail why this happens, Table 3 and Table 4 show more closely the process of mathematical critical thinking and problem solving based on the stages of solving problems by students on each test that has been done. From Table 3, the average percentage information in the Inference, Deduction, and Interpretation process in PBL implementations has doubled when compared to the implementation of PBL combined with PHET. Even in the other two mathematical critical thinking processes, the application of PBL still outperforms the application of PBL combined with PHET.

This phenomenon is certainly inseparable from the conditions in the field when research takes place. When PBL learning combined with PHET, the availability of laptops or mobile phones as a limited PHET support is an obstacle in itself. Many students do not bring laptops or mobile phones, there are even mobile phones that are not specifically supportive in accessing PHET. It affects every media played by more than 2 children. This condition certainly affects students' understanding in using PHET media, because they have to share it with other friends. Finally, the messages obtained from PHET media during learning are less well received by students.

**Table 3.** Characteristics of mathematical critical thinking ability

| Stages | PBL Combined PHET | | PBL | |
|---|---|---|---|---|
| | f | % | f | % |
| Inference | 43 | 15.93 | 82 | 27.61 |
| Recognition of Assumption | 13 | 4.82 | 16 | 5.39 |
| Deduction | 4 | 1.48 | 14 | 4.71 |
| Interpretation | 13 | 4.82 | 26 | 8.75 |
| Evaluation of Arguments | 11 | 4.07 | 16 | 5.39 |

Based on Table 3, information was also obtained that the deduction stage gives the lowest result among the other five stages. If explored further why it happens, because it is more because there is a menu from PHET that does not provide a vehicle for students to provide arguments related to the discrepancy between the information they obtain and the assumptions they have. Like the appearance of PHET explore the main menu of the following problem solving which is considered not in accordance with student expectations because it is considered less futuristic.

Furthermore, from Table 4, information was obtained that the percentage of the three PBL implementation processes combined with PHET (aspects of Select a Strategy, Find an Answer, and Reflect and Extend) was 6% below PBL Not only that, in the Read and think process also has a percentage of almost half of the acquisition of PBL implementation. These facts explain the previous description that the application of PBL combined with PHET does not have a significant difference compared to the application of PBL to problem solving capabilities. Only in the Explore and Plan aspect, the application of PBL

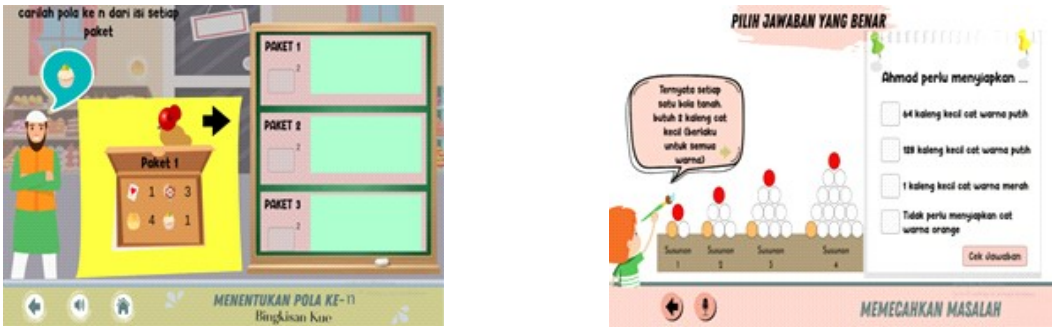


**Figure 2.** One of the PHET displays on the main menu explore

combined with PHET is superior to the application of PBL.

Problem solving skills possessed by *MTs* students, related to how these students build their mindset to solve existing problems. In fact, when PHET media is given to students, the first thing that looks like it is enthusiasm. But when the test is given, most of them are only able to rewrite the information obtained. As for the next stage, there are not many students who can continue it. It could be that what happens is that they only use PHET media as a distraction in learning, without carefully capturing the information provided. Another factor that occurs is the limited time for them to synchronize PBL, PHET media, and their mindset in constructing the material provided.

**Table 4.** Characteristics of problem solving ability

| Aspects | PBL Combined PHET | | PBL | |
|---|---|---|---|---|
| | f | % | f | % |
| Read and think | 40 | 14.82 | 80 | 26.94 |
| Explore and Plan | 7 | 2.59 | 4 | 1.35 |
| Select a Strategy | 36 | 13.33 | 56 | 18.86 |
| Find an Answer | 38 | 14.07 | 46 | 15.49 |
| Reflect and Extend | 6 | 2.22 | 10 | 3.37 |

Similar to the ability to think critically, the explore and plan aspect at the stage of problem solving ability is a stage related to the synchronization of information with diagrams and images. This is also less obtained when in PBL learning combined PHET because PHET does not always display information with images. In addition, the reflect and extend aspect of PHET is not available in the features that students can use to check or review solving problems that have been resolved, as illustrated below. This factor also affects the implementation of PBL combined with PHET is no better than PBL in problem solving capabilities.


**Figure 3.** One of PHET's features in reflect and extend aspects

From the previous exposure, overall the results obtained showed that the application of PBL more affected the ability of problem solving and mathematical critical thinking of students compared to the application of PBL combined with PHET. This finding contradicts Putranta & Kuswanto (2018) and Putranta & Wilujeng (2019) who found that the application of PhET can improve critical thinking skills in physics learning. Yuliati, Riantoni, & Mufti (2018) also found that the application of PhET successfully improved students' problem solving ability in physics learning. In fact, the development of PHET is an adaptation of PhET. The features in PHET are made in such a way as to give students the freedom to explore the media with the aim of facilitating the achievement of explore and plan indicators and recognition of assumptions. Of course, this is inseparable from the current learning conditions, especially in Indonesia. As online learning progresses, students are faced with learning that constantly uses technology to support their knowledge. Even various forms of problem exercises, materials, and even tasks are also done with the help of technology. Finally, when offline learning takes place and teachers apply that learning also with the help of technology, students tend to miss the defenders without the help of technology.

In relation, there is no change in problem solving ability when applied PBL learning combined with PHET, if examined further there is a relationship with student competence. Not all students have the ability to perform problem solving strategies that are demanded by collaborating the knowledge they have. This is also revealed by Williams & Noyes (2007), for students who are early in dealing with contextual problems, they will have difficulty in managing their knowledge literacy which results in the way they pour answers to the problems given (Kusaeri & Ridho, 2019). This is because the ability of problem solving is largely determined by the initial knowledge of students (Castillo-Megchun, López-Rossell, Padilla-Rivera, Villalo-bos-Molina & Tapia-Pancardo, 2021).

If you look deeper into the cause of the above events, of course, it cannot be separated from the features in PHET. As in the description, that the PHET developed does not support the process of synchronizing the information provided to students. Hariyanto & Jannah (2020) in their research explained that learning media that is easily accepted by students is a medium that can support students to understand the knowledge in question. If the features presented in PHET do not support the purpose of creating the media, of course students have difficulty in feeling the real impact.

On the other hand, PHET is a modern game-based learning medium. More effort is needed to unify between learning materials, game characteristics, and learning processes (Liao & Shen, 2012). Of the three aspects should be perfectly integrated, as it will describe the interactive relationship of how students learn from the games presented. Otherwise, students may not be able to separate the material learned through the game, which has an impact on the inability to strategize problem solving and material expansion.

If students have not been able to take over responsibility for their own learning, then game-based learning media such as PHET will actually break their concentration (Pritami & Muhimmah, 2018). Students will be faced with a cognitively "dead" process to conduct the next completion experiment. Eventually they revolve around the problems of "what should I do?" and "how do I do it?" which results in frustration with themselves (Montague & Applegate, 2000).

Furthermore, regarding the ability to think critically mathematically, the data shows that the percentage of this ability in the inference, deduction and interpretation processes in the application of ordinary PBL increased twice compared to PBL combined with PHET. The common thread of it

lies in the student's ability to make a conclusion or inference. Inference is the first stage and the first step of students to apply the stages of critical thinking ability (Fuchs, 2015). Creating inference is a predictor of students' mathematical performance (Rosnawati, Johar & Abidin, 2019). Furthermore, math problems often require more than what students think (Kusaeri, 2020). They must be able to express in an explicit written way and require the ability to make inferences. This is what has not been able to be revealed by the features of PHET that support the ability of students to compile inference explicitly.

Instead, deduction is the ability to provide reasons related to the mismatch between the information obtained and the assumptions built by students. At this stage it seems that the information obtained by students from PHET media has not been in sync with the abilities possessed by them. Creating inference is a key component in deducting (Abrami, Bernard, Borokhovski, Waddington, Wade & Persson, 2015). For this reason, a gradual process is needed to trigger students' knowledge in order to be connected to the implementation of PBL combined with PHET media. These actions help students to bring up the ability to interpret, which can eventually develop students' mathematical critical thinking skills.

From a series of previous reviews, the lack of effectiveness of PBL combined with PHET in improving the ability to think critically mathematically due to several factors. The first factor, there is still a shock of the change in defenders from online patterns to offline (limited face-to-face). As online learning progresses, students are faced with learning that constantly uses technology to learn their knowledge. Finally, when offline learning takes place and teachers apply that learning also with the help of technology, students tend to miss the defenders without the help of technology. The presence of PHET used in this research in the end, is only considered a time-filling game. Finally, the message that wants to be conveyed that PHET as a learning medium is less than optimal. The second factor, the various features developed in PHET are still not optimal. This fact is certainly reasonable, considering that there are not many PHET learning media used to support mathematics learning. PHET media more developed in science learning.

## ■ CONCLUSIONS

Some important findings of this research are presented as follows: (a) there is no difference in the influence of intervention on the application of PBL combined with PHET with the usual PBL group in developing students' mathematical problem solving abilities, and (b) there are differences in the influence of interventions on the implementation of PBL integrated PHET and the application of ordinary PBL in developing students' critical thinking skills.

Various limitations were also found in this research, for example, some features in PHET media have not considered the psychological condition of students during the process of trnasisi from online to offline learning systems. The lack of computers during the implementation of PHET media integrated with PBL in the field also surrounds this research. Both of these things are suspected to have a maximum share of the impact of phet media implementation integrated with PBL on mathematical critical thinking skills and problem solving. This fact indicates the importance for mathematics teachers to be more careful in developing features in PHET media that are in accordance with the psychological condition of students. In addition, the availability of computers to access website-based media also needs to get the attention of teachers so that learning becomes more effective, a maximum of two students to access one computer device.

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## Appendix

**Tabel 1.** Instrumen untuk mengukur kemampuan berpikir kritis matematis dan problem solving

**Item Soal Nomor 1:**

Di Jalan Ahmad Yani, terdapat sebuah lampu lalu lintas yang memiliki durasi sebagai berikut:

| Warna Lampu | Durasi |
|---|---|
| Merah | 25 detik |
| Kuning | 5 detik |
| Hijau | 20 detik |

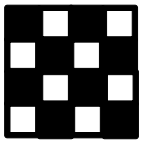
Pergantian lampu lalu lintas secara berturut-turut yakni lampu merah, lampu kuning, lampu hijau, lampu kuning, kemudian kembali lagi ke lampu merah yang selanjutnya dilakukan berulang-ulang. Jika tepat pada pukul 09.00:01 menyala lampu warna merah, maka pada pukul 09.20 lampu yang menyala adalah warna…

Karakteristik Tes: Menyajikan informasi yang diketahui dan ditanyakan yang dapat diubah ke bentuk barisan bilangan dan dapat diintegrasikan dengan pengetahuan sebelumnya.

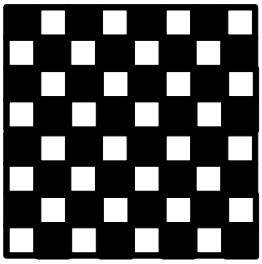
| Kegiatan yang Dilakukan Siswa | Indikator Berpikir Kritis Matematis | Indikator Problem Solving |
|---|---|---|
| Siswa menyajikan ulang informasi yang diberikan ke dalam bentuk model matematika, yakni lampu merah menyala setiap 25 detik, lampu kuning setiap 5 detik, dan lampu hijau setiap 20 detik. | *Read and Think* | *Inference* |
| Siswa mengetahui jika soal yang disajikan merupakan materi pola bilangan dan mampu mengintegrasikannya dengan materi yang telah diterima sebelumnya. | *Explore and Plan* | *Recognition of Assumption* |
| Siswa menelaah informasi yang diberikan oleh soal, apakah telah memenuhi syarat-syarat untuk dilakukan perhitungan dengan menggunakan konsep pola bilangan, yakni dengan membuktikan jika pukul 09.00 menyala lampu warna merah berdasarkan konsep pola bilangan. | | *Deduction* |
| Siswa membuat ilustrasi penyelesaian untuk mencari tahu lampu yang menyala pada pukul 09.20 berdasarkan temuan-temuan sebelumnya | *Select a Strategy* | *Interpretation* |
| Siswa menemukan jawaban bahwa lampu yang menyala tepat pada pukul 09.20 adalah lampu berwarna hijau | *Find an Answer* | |
| Siswa mampu memberikan alasan yang kuat atas temuan jawaban yang telah diperoleh | *Reflect and Extend* | *Evaluation of Arguments* |

**Item Soal Nomor 2:**

Pak Ilham adalah seorang tukang bangunan yang sedang memasang keramik di sebuah gedung. Keramik yang dipasang terdiri dari 2 warna yakni keramik warna hitam dan keramik warna putih. Pola pemasangan keramik yang dibuat oleh Pak Ilham yakni:



Ukuran Ruangan
1 meter x 1 meter



Ukuran Ruangan
2 meter x 2 meter

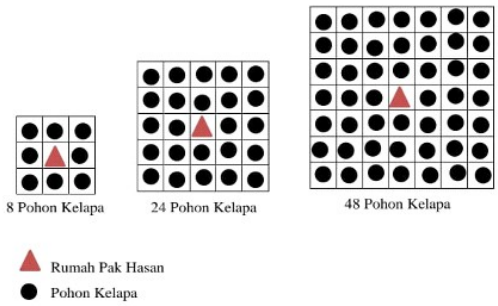
Apabila ukuran ruangan yang akan di pasang keramik oleh Pak Ilham sebesar 10 meter x 10 meter dan pola pemasangan keramik sama seperti gambar di atas, maka banyak keramik hitam yang diperlukan Pak Ilham adalah…

Karakteristik Tes: Menyajikan informasi yang diketahui dan ditanyakan yang dapat dirubah ke bentuk tabel dan permasalahan dapat dikembangkan.

| Kegiatan yang Dilakukan Siswa | Indikator Berpikir Kritis Matematis | Indikator Problem Solving |
|---|---|---|
| Siswa menyajikan ulang informasi pada gambar ke dalam model matematika terkait warna dan ukuran keramik. | *Read and Think* | *Inference* |
| Siswa menyajikan informasi ke dalam bentuk tabel untuk menggambarkan hubungan ukuran ruangan dengan banyak keramik. | *Explore and Plan* | *Recognition of Assumption* |
| Siswa menelaah tabel yang dibuat dengan informasi gambar yang disajikan. | | *Deduction* |
| Siswa menentukan strategi untuk mengetahui perbandingan jumlah keramik hitam dan putih pada setiap ruangan. | *Select a Strategy* | *Interpretation* |
| Siswa menemukan jawaban 800 keramik | *Find an Answer* | |
| Siswa menemukan alasan yang kuat atas jawabannya dan mengembangkan masalah dengan menghitung biaya yang seandainya dikeluarkan. | *Reflect and Extend* | *Evaluation of Arguments* |

**Item Soal Nomor 3:**

Akibat meningkatnya kasus Covid-19 di Indonesia, masyarakat berbondong-bondong memburu multivitamin untuk menjaga Kesehatan tubuh. Salah satu multivitamin yang banyak diburu adalah multivitamin minyak kelapa murni atau *Virgin Coconut Oil* (VCO). Pak Hasan, salah satu pemilik kebun kelapa menyatakan ada peningkatan permintaan buah kelapa selama pandemic ini. Oleh karena itu, Pak Hasan melakukan perluasan kebun kelapa untuk memenuhi permintaan konsumen, yang dirancang sebagai berikut:



Setiap kali berbuah, satu pohon kelapa dapat menghasilkan 12 buah setiap rumpunya, dan setiap pohon kelapa rata-rata memiliki 6 rumpun. Ilustrasi perluasan kebun yang harus dirancang Pak Hasan jika permintaan mencapai 12.096 buah adalah …

Karakteristik Tes: Menyajikan informasi yang diketahui dan ditanyakan yang dapat dirubah ke bentuk tabel dan dapat diintegrasikan dengan pengetahuan sebelumnya.

| **Kegiatan yang Dilakukan Siswa** | **Indikator Berpikir Kritis Matematis** | **Indikator Problem Solving** |
|---|---|---|
| Siswa menyajikan ulang informasi terkait banyak rumpun dalam satu pohon dan gambar pola bilangan. | *Read and Think* | *Inference* |
| Siswa menyajikan informasi ke dalam bentuk tabel untuk menggambarkan hubungan ukuran kebun dan banyak pohon. | *Explore and Plan* | *Recognition of Assumption* |
| Siswa menelaah tabel yang dibuat dengan informasi gambar yang disajikan. | | *Deduction* |
| Siswa mencari rumus pola bilangan dengan bantuan tabel. | *Select a Strategy* | *Interpretation* |
| Siswa menemukan jawaban pertanyaan (a) bernilai salah (b) bernilai benar, (c) bernilai benar. | *Find an Answer* | |
| Siswa mampu memberikan alasan yang kuat atas temuan jawaban yang telah diperoleh | *Reflect and Extend* | *Evaluation of Arguments* |