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# Effect of PBL-Based Scratch E-module in Improving Computational Thinking and Physics Concepts

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# Effect of PBL-Based Scratch E-module in Improving Computational Thinking and Physics Concepts

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**Abstract**

The rapid and sophisticated development of science and technology requires education to present learning by developing IT skills in students. At the same time, mastery of physics concepts is needed to solve abstract problems. This material packaged using technology and computer programming can be an alternative solution to this problem. This study aims to measure the improvement of computational thinking and physics concepts of senior high school students in applying the problem-based learning-based Scratch experimental module. This research method is quantitative with a quasi-experimental design of the type of Pretest-Posttest Control Group Design. The results showed a significant increase in computational thinking skills in order changing straight motion, free fall motion, vertical upward motion, and concept mastery after using the E-module Scratch experiment based on problem-based learning for high school students are significant. Based on the results of this study, it can be interpreted that using the Scratch digital experimental E-module can improve computational thinking skills and physics concepts.

## Introduction

Education has entered the 21st century in the era of the industrial revolution 5.0 with fast and sophisticated science and technology. A country needs to prepare itself with appropriate technical knowledge to compete, namely by bridging digital tensions using technological and scientific capabilities (Voskoglou & Buckley, 2012; Gretter & Yadav, 2016; Tsai & Tsai, 2018). One way that can be done to face these challenges is to master skills that can be improved by combining science and technology, namely computational thinking (CT). This is supported by research by Jeannette Wing, vice president of Microsoft and US National Research Council states that everyone must learn to think processing (computational thinking) to face the world of work (Wing, 2008). CT is the problem-solving skills by adopting computer programming concepts such as decomposition, abstraction, algorithms, and pattern recognition in problem formulation (Wing, 2006).

The researchers conducted a preliminary study on 15 high school / vocational high school teachers in the Central Java region, Indonesia, namely Semarang, Ungaran, Kendal, Pekalongan, Tegal, and Kudus. The selection of school representatives who were sampled with reason to obtain data on the need for CT skills in physics lessons for each school used in Central Java by random sampling. The information contains that CT skills are needed by students studying physics. This is necessary to keep up with the era of digital development, and students support online and offline learning organized by the government using digital media. CT can describe the studied material face-to-face to make independent simulations so students can solve physics problems systematically and analytically.

CT skills can support student learning opportunities with a learning approach that allows students to explore, discuss, and meaningfully build concepts and relationships involving real problems with relevant projects (authentic learning) to prepare students for global warfare (Wing, 2008; Papadakis et al., 2016; Adler & Kim, 2018; Lee & Jiang, 2019). CT is significant to teaching because this skill is a comprehensive problem-solving technique, not only to solve problems related to computer science but also to solve varied problems in everyday life that are abstract. In addition, CT can support ideas and mastery of physics concepts and the application of various fields of science.

Physics is a science that has few concepts that require high analytical and logical skills for the abstract draft. The physics concept can be understood with the experience of observing everyday phenomena and events. Physics concept is hard to know valid and finished students, especially in high school. The students often understand the concept of physics based on the logic and experience they have of everyday events that are experienced or seen directly without physically analyzing the correct physics concepts by the experts. Many students do not know how to start working on the questions they only remember the formulas they memorized without knowing how to solve the problem correctly (Sari, 2019). Mastery of physics concepts is significant in the learning process because it can help students have the base provisions to achieve other basic abilities such as reasoning, communication, connection, and problem-solving.

Teachers demand to own the correct steps toward CT results and mastery of students' physics concepts. Specify the success rate of CT skills and physics concepts to support learning in the era of the industrial revolution 5.0 using tools that can promote these skills. Physics learning is oriented towards improving CT skills with mastery of concepts that can be done through the exertion of digital devices.

One of the tools that can improve CT and mastery of concepts is Scratch (Dwyer et al., 2014; Serbec et al., 2015; Marcelino et al., 2018; Fidai et al., 2020). The Scratch learning tool supports free forms of programming (without thinking about right or wrong in syntactic writing) that can help in reflection and mastery of students' scientific concepts and attitudes (Vacca, 2019). This is supported by the support of two-dimensional Scratch-based learning media that can help students master abstract physics concepts (Martanti et al., 2014; Setiawan, 2020). Scratch features a simple programming language adapted for primary and secondary school students (Lopez & Hernandez, 2015; Papadakis et al., 2016; Noftiana et al., 2019). Scratch is also increasingly being used in schools because it allows using tools to build scientific models and evaluate learning (Wing, 2006). A preliminary study in 15 schools revealed that as many as 86.7% of teachers already knew Scratch, and 13.3% did not know the Scratch application. If further traced from the data of teachers who already know Scratch, only 33.3% of teachers have made Scratch learning media, while 53.4% have never used it. Thus, although the Scratch application has been known by some teachers yet not many have used the Scratch application to improve CT and students' mastery of concepts in physics lessons. This is because there is no experience in applying Scratch, only limited to using physics simulation applications till it does not allow them to make simulations independently so that they can measure CT.

Based on the results of observations at SMA N 8 Semarang, it was found that 1) the teacher had carried out experiments but had never measured students' CT. 2) students' mastery of concepts is still limited to the cognitive domains of C1, C2, and C3, while C4 and C5 are still rarely used by teachers. 3) The teacher uses the quiz method by Quipper students tend to be passive in class because physics is considered complicated. After knowing the potential and problems in learning activities at SMA N 8 Semarang, it was decided to develop a teaching material that can be accessed online and offline containing material that can also be used as a digital experiment. Teaching materials that can be used are modules in electronic form or E-modules.

A module is a set of teaching materials presented systematically so users can learn with or without a teacher or facilitator (Sagita et al., 2017; Tania, 2017). Modules are studied by students in printed form, along with the growth of information and communication technology. The print module has been replaced by an electronic module (E-module) (A. D. Puspitasari, 2019). If viewed from the benefits of electronic media itself, it can make the learning process more interesting, and interactive can be done anytime and anywhere can improve the quality of learning (Mayanty et al., 2018; A. D. Puspitasari, 2019). E-module is teaching materials that require students' independence to find a concept (Mayanty et al., 2018).

## Method

The method used in this research is quantitative research. The research design used was a quasi-experimental type of Pretest-Posttest Control Group Design. The pretest was held before and post-test after implementing the PBL-based Scratch experimental e-module. The research design can be described in Table 1.

Table 1. Quasi-Experimental Research Design

| **Pretest** | **Treatment** | **Post-test** |
|---|---|---|
| $O_1$ | X | $O_3$ |
| $O_2$ | | $O_4$ |

Information:

| | | | |
|---|---|---|---|
| $O_1$ | : Pretest eksperimental class | $O_3$ | : Post-test eksperimental class |
| $O_2$ | : Pretest control class | $O_4$ | : Post-test control class |
| X | : Treatment | | |

The research was carried out at SMA Negeri 8 Semarang for the academic year 2021/2022 located at Jalan Raya Tugu, Tambakaji, Kec. Ngaliyan, Semarang, Central Java, Indonesia. The sample used in this study was a purposive sampling technique with the judgment of the homogeneous average midterm exact score so that two classes were obtained, namely X MIPA 1 as the experimental class and X MIPA 5 as the control class amount of 36 students each. The data collection techniques used in this study were initial observations, written tests, and documentation. Data analysis techniques are normality tests, significance tests, and N-gain tests.

## Results

The module used in this study is a PBL-based E-module on class X rectilinear motion material. The E-module raises rectilinear motion material using digital Scratch experiments. This is based on preliminary studies that research in schools is rarely done during the pandemic period. Mastery of concepts is still limited to the cognitive domains C1, C2, and C3. Then C4 and C5 are less used by teachers with low interaction and a lack of use of digital technology in learning physics. Digital devices such as smartphones/laptops/PCs that are connected to the internet have a significant role to play in supporting the online learning process, one of which is as a virtual learning medium ranging from virtual class applications, instant messaging applications, social media, to virtual labs (Firdaus, 2020).

The E-module used has an A4 size totaling 67 pages. Subtitles on the E-module are written in a larger font and presented in a box. In addition to subtitles, equations and video barcodes in the E-module are served in a box. The opinion of Ayub et al. (2019) and Wulandari et al. (2020) is information can be emphasized using boxes. The e-module is equipped with pictures in each material, videos in the form of barcodes, and simulations to make it easier for students to understand physics concepts because Puspitasari et al. (2020) E-module equipped with pictures and videos can help students understand the material coherently and the use of multimedia devices in teaching materials in the form of simulations can make learning more effective (Aji et al., 2017; Haryadi & Jannah, 2020). The e-module used in this study is shown in Figure 1.


Figure 1. PBL-based Scratch E-module experiment

The e-module used has programming content with the Scratch software. The e-module includes the PBL syntax, including orienting students to problems, organizing learning activities, guiding independent investigations, presenting work analysis, and evaluation. The PBL syntax is packaged in learning activities in the E-module, namely learning materials, sample questions, and practice questions for each material. This approach can make students learn actively in bold learning. This PBL-based Scratch experimental e-module has the advantage of using digital devices owned by students. In addition, the E-module can be accessed offline.

**Improvement of Student CT**

The increase in CT students as measured using the assessment project before and after using the PBL-based Scratch E-module experiment in class X SMA N 8 Semarang totaled 72 students. The CT studied in this study has aspects of pattern recognition, decomposition, abstraction, and algorithmic thinking. Student CT can be built by making simulations using Scratch programming. CT students were tested on straight motion material, namely uniformly accelerated motion, free fall motion, and upward vertical motion.

*Improved Uniformly Accelerated Motion Material CT*

The results of the normality test for the increase in Uniformly Accelerated Motion material CT are shown in Table 2. The data shows that the value of Sig. > 0.05, that data is normality distributed. Test results show that the experimental class is normality distributed and thus applying parametric statistics, namely t-test. Independent t-test with a significance level of 0.05 with criteria for testing Ha is accepted if t is in the range t-count < t-table with the hypothesis:

Ho: There is no difference in the increase in CT in the material in a Uniformly Accelerated Motion between the control class and the experimental class.

Ha: There is a difference in the increase in CT in the Uniformly Accelerated Motion between the control and experimental classes.

Table 2. Normality Test Results of Uniformly Accelerated Motion

| | | **Kolmogorov-Smirnov[a]** | | | **Shapiro-Wilk** | | |
|---|---|---|---|---|---|---|---|
| | **Class** | **Statistic** | **df** | **Sig.** | **Statistic** | **df** | **Sig.** |
| Computational Thinking | Control | .118 | 36 | .200* | .951 | 36 | .109 |
| Uniformly Accelerated Motion | Experimental | .147 | 36 | .049 | .959 | 36 | .205 |

The results of the t-test from CT Uniformly Accelerated Motion material can be seen in Table 3.

Table 3. Material CT T-Test Results of Uniformly Accelerated Motion

| **Class** | **n** | $\bar{X}$ | $S_x^2$ | $t_{count}$ | $t_{table}$ |
|---|---|---|---|---|---|
| Control | 36 | 66.884 | 158.132 | -9.749 | 1.667 |
| Experiment | 36 | 88.998 | 27.083 | | |

It can be seen that the t-count results of students' mastery of physics concepts are -9.749 while the t-table is 1.667. This shows that t-count is in the area of rejection, that is Ho is rejected, and Ha is accepted, so it can be concluded that there is a significant difference in concept mastery between the control and experimental class. Apart from being analyzed classically, the increase in CT was also seen based on the item items. The increase in CT Uniformly Accelerated Motion based on the item is presented in Table 4.

Table 4. Results of Improved CT Uniformly Accelerated Motion

| No | Aspect CT | Enhancement (%) | | |
|---|---|---|---|---|
| | | Theory | Practice | Average |
| 1 | Pattern recognition | 46.75 | 71.00 | 58.88 |
| 2 | Decomposition | 29.00 | 96.00 | 62.50 |
| 3 | Abstraction | 74.34 | 97.50 | 85.92 |
| 4 | Algorithm | - | 91.67 | 91.67 |

Based on Table 4, the average percentage increase from the highest pretest to posttest CT in the algorithm aspect has increased by 91.67% since students build simulations from Scratch scripts by formulation, theory, and law of physics. The lowest percentage of achievement in the pattern recognition aspect is 58.88% are students who can distinguish objects experiencing acceleration and deceleration. The magnitude of the increase in CT in the control class and experimental class in the material of uniformly changing rectilinear motion can be seen in Table 5.

Table 5. N-Gain CT Test Results of Uniformly Accelerated Motion

| Class | Average | | N-Gain |
|---|---|---|---|
| | Pre-test | Post-test | |
| Control | 21.187 | 66.885 | 0.580 |
| Experiment | 23.802 | 88.998 | 0.856 |

Based on Table 5, it is known that the N-Gain result in the control class is 0.580. This shows that the increase in the control class is in the moderate category. The experimental class has an N-Gain result of 0.856 increase in the high category.

The results test of CT can be seen that after students use the PBL-based Scratch experimental E-module on Uniformly Accelerated Motion material in learning glasses, the average student CT sales are good. Table 4 shows that the lowest aspect of CT improvement in GLBB material is pattern recognition, with an average increase in theory and practice of 58.88%. This aspect is variables in straight motion and modifying the motion of objects. Pattern recognition is low because problems are presented, and students then identify, identify, and develop the variables containing a straight-line motion that changes uniformly. This motion is a horizontal movement often encountered by students so that in the pre-test, students understand what variables are contained even though it is incomplete.

*Free Fall Material CT Improvements*

The results of the normality test for the increase in CT of the Free Falling Motion material are shown in Table 6.

The data shows that the value of Sig. > 0.05 means that the data is normally distributed. The test results show that the experimental class is normally distributed, so it uses parametric statistics, namely the t-test. The independent t-test with a significance level of 0.05 with the criteria for testing Ha is accepted if t is in the range t-count < t-table with the hypothesis:

Ho: There is no difference in the increase in CT in free fall motion material between the control and experimental class.

Ha: There is a difference in the increase in CT in free fall motion material between the control and experimental classes.

Table 6. Posttest Normality Test Results of Free Fall Motion

| | | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | **Class** | **Statistic** | **df** | **Sig.** | **Statistic** | **df** | **Sig.** |
| Computational Thinking Free Fall Motion | Control | .135 | 36 | .097 | .946 | 36 | .076 |
| | Experimental | .130 | 36 | .132 | .943 | 36 | .064 |

The results of the t-test from the free-fall motion material CT can be seen in Table 7.

Table 7. CT t-test results of free-falling material

| **Class** | **n** | $\bar{X}$ | $S_x^2$ | $t_{count}$ | $t_{table}$ |
|---|---|---|---|---|---|
| Control | 36 | 71.986 | 136.455 | -6.805 | 1.667 |
| Experiment | 36 | 87.326 | 46.473 | | |

The results of t-count CT for students' physics free fall were -6.805, while the t-table was 1.667. This shows that the t-count is in the rejection area. Ho is rejected, and Ha is accepted, so it can be concluded that there are significant differences in CT in free fall motion material between the control and experimental class. Apart from being analyzed classically, the increase in CT was also seen based on the item items. The increase in CT in free fall motion material based on the aspect is presented in Table 8.

Table 8. Results of Increasing Free Fall Material CT

| **No** | **Aspect CT** | **Enhancement (%)** | | |
|---|---|---|---|---|
| | | **Theory** | **Practice** | **Average** |
| 1 | Pattern recognition | 47.00 | 92.00 | 69.50 |
| 2 | Decomposition | 12.50 | 99.00 | 55.75 |
| 3 | Abstraction | 69.50 | 97.00 | 83.25 |
| 4 | Algorithm | - | 98.00 | 98.00 |

Based on Table 8, the percentage increase from pretest to posttest CT in free fall material is the highest in the algorithm aspect at 98%. The lowest percentage of achievement on the decomposition aspect is 55.75%. The magnitude of the CT increase in the control and experimental class in free fall motion material can be seen in Table 9.

Table 9. N-Gain CT Test Results of Free Falling Materials

| Class | Average | | N-Gain |
|---|---|---|---|
| | Pre-test | Post-test | |
| Control | 19.149 | 71.986 | 0.654 |
| Experiment | 22.104 | 87.326 | 0.837 |

Based on Table 9, it is known that the N-Gain result in the control class is 0.654. This shows that the increase in the control class is in the moderate category. The experimental class has N-Gain results of 0.837, indicating a high category.

The results of CT achievement after students use the PBL-based Scratch experimental E-module on free fall motion material in physics learning, the average student CT achievement is quite good. Table 8 shows the lowest aspect of CT increase in free fall motion material is decomposition, with an average in theory and practice of 55.75%. This aspect is an interpretation relationship between variables in free fall motion, understanding the concept of free fall motion. Decomposition is low because students already know the relationship between height and speed in free fall. This motion is a vertical motion often encountered because the problem is the motion of objects falling from a certain height. In the pre-test, students understand that the lower position of the object, the higher the speed of the object.

*Upward Vertical Motion Material CT Improvements*

The results of the normality test for the increase in CT material for vertical upward motion are shown in Table 10. The data shows that the value of Sig. > 0.05 data is normally distributed. The test results show that the experimental class is normally distributed, so it uses parametric statistics, namely the t-test. The independent t-test with a significance level of 0.05 with the criteria for testing Ha is accepted if t is in the range t-count < t-table with the hypothesis:

Ho: There is no difference in the increase in CT in the vertical upward motion material between the control and experimental class.

Ha: There is a difference in the increase in CT in the vertical upward motion material between the control and experimental classes.

Table 10. Normality Test Results of Upward Vertical Motion

| | | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|---|
| | Class | Statistic | df | Sig. | Statistic | df | Sig. |
| Computational Thinking Upward Vertical Motion | Control | .134 | 36 | .104 | .942 | 36 | .057 |
| | Experimental | .135 | 36 | .094 | .961 | 36 | .230 |

The results of the t-test from the material CT moving vertically upwards can be seen in Table 11. It can be seen that the results of the t-count CT of the material for students' vertical upward motion are -6.986, while the t-table is 1.667. This shows that t-count is in the area of rejection, namely Ho is rejected and Ha is accepted so it can be concluded that there is a significant difference in CT of the vertical upward motion material between the control class and the experimental class. Apart from being analyzed classically, the increase in CT was also seen based on the item items.

Table 11. CT T-Test Results of Upward Vertical Motion Material

| Class | N | $\bar{X}$ | $S_x^2$ | $t_{count}$ | $t_{table}$ |
|---|---|---|---|---|---|
| Control | 36 | 67.419 | 361.895 | -6.986 | 1.667 |
| Experiment | 36 | 90.509 | 31.360 | | |

The increase in CT material for vertical upward motion based on the item items is presented in Table 12.

Table 12. Results of Increasing Upward Vertical Motion Material CT

| No | Aspect CT | Enhancement (%) | | |
|---|---|---|---|---|
| | | Theory | Practice | Average |
| 1 | Pattern recognition | 44.00 | 82.00 | 63.00 |
| 2 | Decomposition | 23.00 | 97.00 | 60.00 |
| 3 | Abstraction | 74.50 | 95.50 | 85.00 |
| 4 | Algorithm | - | 96.67 | 96.67 |

Based on Table 12, the highest percentage increase from pretest to posttest CT on the vertical upward motion was in the algorithm aspect of 96.7%, while the lowest percentage was in the decomposition aspect of 60%. The magnitude of the CT increase in the control class and experimental class in the vertical upward motion material can be seen in Table 13.

Table 13. Results of the CT N-Gain Test for Upward Vertical Motion Material

| Class | Average | | N-Gain |
|---|---|---|---|
| | Pre-test | Post-test | |
| Control | 18.900 | 67.419 | 0.598 |
| Experiment | 22.049 | 90.509 | 0.878 |

Based on Table 13, it is known that the N-Gain result in the control class is 0.598. This shows that the increase in the control class is in the moderate category. The experimental class has an N-Gain result of 0.878, indicating a high category.

The results of CT achievement show that after students use the PBL-based Scratch experimental E-module in the material of vertical upward motion learning physics, the average student CT achievement is quite good. Table 12 shows that the lowest aspect of the increase in CT in the vertical upward motion material is decomposition, with an average in theory and practice of 60.00%. This aspect interpretation of the relationship between variables in the upward vertical motion, understanding the concept of the upward vertical motion. The increase in decomposition is low because students already know the relationship between height and speed of vertical upward motion. This motion is a vertical motion often encountered because of the problem motion of the ball being thrown perpendicularly upwards so that students understand that the higher the object, the slower the ball speed.

**Improvement of Physics Concepts**

The increase in mastery of physics concepts using the PBL-based Scratch experimental E-module is known from the results of a large-scale trial in class X SMAN 8 Semarang, which has a total of 70 students. The concept mastery test was given before (pre-test) and after (post-test) in the experimental and control class. The results of the normality test for increasing mastery of the concept are shown in Table 14.

Table 14. Test of Students' Concept Normality

| | | **Kolmogorov-Smirnov[a]** | | | **Shapiro-Wilk** | | |
|---|---|---|---|---|---|---|---|
| | **Class** | **Statistic** | **df** | **Sig.** | **Statistic** | **df** | **Sig.** |
| Concept Mastery | Control | .129 | 35 | .154 | .952 | 35 | .131 |
| | Experimental | .113 | 35 | .200* | .954 | 35 | .151 |

The data shows that the value of sig. > 0.05, the control and experimental class data are normally distributed. The test results show that the experimental class is normally distributed so it uses parametric statistics, namely the t-test. The independent t-test with a significance level of 0.05 with the criteria for testing Ha is accepted if t is in the range t-count <t-table with the hypothesis:

Ho: There is no difference in increasing mastery of concepts between the control class and the experimental class.

Ha: There is a difference in the increase in mastery of concepts between the control and experimental classes.

Table 15. The Results of the T-test for Physics Concepts

| **Class** | **n** | $\bar{X}$ | $S_x^2$ | $t_{count}$ | $t_{table}$ |
|---|---|---|---|---|---|
| Control | 35 | 42.86 | 16.340 | -28.990 | 1.668 |
| Experiment | 35 | 80.82 | 43.665 | | |

The results of the t-test of concept mastery can be seen in Table 15. It can be seen that the t-count results of students' mastery of physics concepts are -28.990 while the t-table is 1,668. This shows that t-count is in the area of rejection, Ho is rejected, and Ha is accepted, so it can be concluded that there is a significant difference in the mastery of the concept between the control and experimental class. The magnitude of the results of increasing the physics concept of each aspect is shown in Figure 2.

Based on Figure 2, the highest increase in mastery of concepts is aspect C2, while the lowest percentage of achievement is aspect C5. This can happen because first, students still need adjustments to learning using the PBL-based Scratch experimental E-module still relatively new to students. Second, the teacher rarely gives questions or problems regarding mastery of concepts related to aspects of C5 students are not used to solving problems with these aspects.

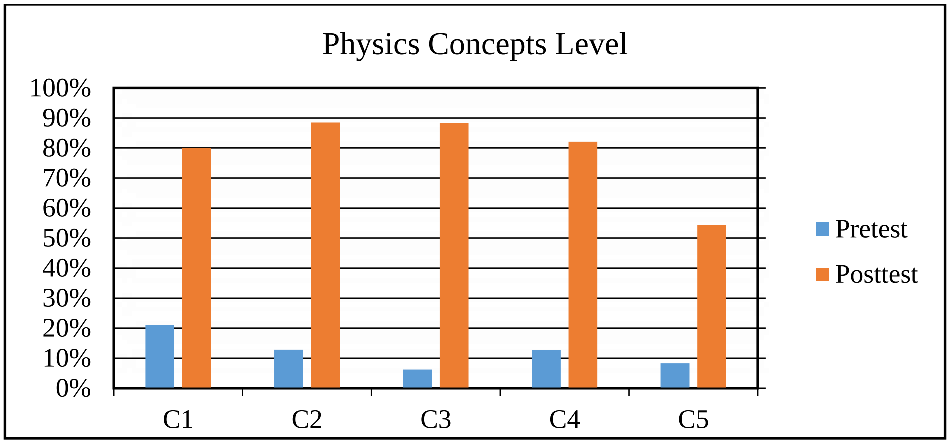


Figure 2. Improved of Physics Concepts

The magnitude of the increase in mastery of physics concepts in the control and experimental classes can be seen in Table 16. The control class has an N-Gain result of 0.379 indicating that the increase in students' mastery of concepts in the control class is in the medium category. The N-Gain result in the experimental class is 0.782. This shows that the increase in students' mastery of concepts in the experimental class is in the high category.

Table 16. N-Gain Test Results for Physics Concepts

| **Class** | **Average** | | **N-Gain** |
|---|---|---|---|
| | **Pre-test** | **Post-test** | |
| Control | 7.959 | 42.857 | 0.379 |
| Experiment | 11.293 | 80.680 | 0.782 |

## Discussion

### Improvement of CT

Based on the results of a PBL-based Scratch experimental E-module can increase the CT of class X students in straight-motion material. It can be seen from the N-Gain CT in the experimental and control group. The CT studied in this study has aspects of pattern recognition, decomposition, abstraction, and algorithmic thinking. CT can be built by making simulations using Scratch programming. CT was tested on straight motion material, namely uniformly accelerated, free-fall, and upward vertical motion. In the sub-chapter on uniform acceleration motion, significant differences in the problem of CT between the control and experimental classes. Based on the results of the N-Gain test and t-test, it can be seen that the increase in results of CT in uniform acceleration motion for students using the PBL-based Scratch experimental E-module is better (significantly) compared to students who use textbook teaching materials provided by the school.

In the free fall sub-chapter, a significant difference in the CT material in free fall motion between the control and experimental classes. Based on the results of the N-Gain test and t-test, it can be seen that the increase in CT in the free fall motion material of students using the PBL-based Scratch experimental E-module is better (significant) compared to students who use book materials provided by the school. In the third sub-chapter, vertical upward motion, there is a significant difference in the vertical upward motion CT material between the control and experimental classes. Based on the results of the N-Gain test and t-test increase in CT material for vertical upward motion of students who use the PBL-based Scratch experimental E-module is better (significantly) compared to students who use book materials provided by the school.

Based on the results, several factors are the reasons for using the PBL-based Scratch experimental E-module to increase students' CT. One of these factors is learning which creates an energetic atmosphere in solving problems. In the learning process, students face challenges such as difficulty compiling Scratch programming syntax. This solution can be resolved through discussion between students. This shows that learning using the PBL-based Scratch experimental E-module is attractive, fun, educational, and fosters communication. Students in this study were given an example of making a simulation of uniform acceleration motion, and students made a simulation of changing rectilinear motion.

Students in this study made simulations of uniform acceleration, free fall, and vertical upward motion. Students are free to complete their assignments, while the teacher does not intervene much in decision-making because the teacher acts as a facilitator. Students use sources such as the internet, friends, and teachers. This happens because the demands of learning using the PBL-based Scratch experimental E-module require students to actively access, discover, and process various information, one of which is used to build a complete simulation project. Learning through a process like this will make students' information skills, communication, and mastery of technology because students directly build experience and will then form complete knowledge.

Learning using the PBL-based Scratch experimental E-module in its implementation can foster independence in creating their learning. This research by Hasanah *et al*. (2017), Muslim *et al*. (2017), dan Paradina *et al*. (2019) revealed that learning using Scratch would attract more students' attention and interest compared to conventional learning, could learn actively and independently in discovering new knowledge.

**Improvement of Physics Concepts**

The mastery of the concepts studied in this study has aspects, namely C1, C2, C3, C4, and C5. Based on the results using a PBL-based Scratch experimental E-module can improve students' of physics concepts in class X on straight motion materials. This can be seen in the N-Gain value of concept mastery in the experimental and control classes. The increase of physics concepts using the PBL-based Scratch experimental E-module is known from the results of a large-scale trial in class X SMAN 8 Semarang, which has 70 students. In the pilot test, the concept mastery test was given before (pretest) and after (posttest) in the experimental and control class.

Students of physics concepts increase when using the PBL-based Scratch experimental E-module based on the results of large-scale tests in experiment classes. Based on the results of the N-Gain test and t-test increase in students' mastery of concepts using the PBL-based Scratch experimental E-module is better (significant) compared to students who use textbook teaching materials provided by the school. Several factors and reasons for using the PBL-based Scratch experimental E-module that can improve students' mastery of concepts compared to ordinary teaching materials E-module provides sample questions and practice questions regarding material previously mastered using the PBL approach. This is to research by Hasanah et al. (2017), Muslim et al. (2017), and Paradina et al. (2019) that PBL is a learning model in which students are faced with a problem from the start, then followed by searching for information that is student-centered so that it is very suitable to be applied in spectacle learning in the form of concepts, laws, principles, theories related to the scope of everyday problems.

In addition, the PBL-based experimental E-module can improve students' of physics concepts because it utilizes programming or processing activities using Scratch. Making this Scratch programming simulation can create mastery of physics concepts in students. Scratch programming is made in a graphical form of programming where users can use it like playing a puzzle so that it becomes fun to learn. This pleasant condition will build interest and motivation in student learning which is necessary for mastering concepts so that students can actively find concepts in straight-motion material. Students are required to actively analyze how the simulation is built in the form of an analysis starting from the quantities used in a straight motion, and the mathematical equations used to make the Scratch programming syntax. This is consistent with previous research that improvement-based learning has a positive impact, one of which is that improvement-based learning can build students' mastery of physics concepts (Sutopo et al., 2016; Kaniawati, 2017; Niami et al., 2018).

## Conclusion

Based on the results and discussion of the study, it was concluded that (1) there was a significant difference in the increase in CT between the control class and the experimental class, both for the material of straight changing straight motion, free-falling motion, and vertical upward motion, (2) there was a difference in increasing mastery of the concept between control class and experimental class classified as significant. It is recommended that more teachers be involved during the implementation phase of the study, conduct further investigation into other Physics or science topics, and enforce mentoring or peer coaching sessions to supplement teachers’ knowledge and skills.

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