



Brain-Based Learning: The Impact on Student's Higher Order Thinking Skills and Motivation

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ABSTRACT

The research objectives are to determine the effects of the Brain-based Learning (BBL) approach on students' higher-order thinking skills and student motivation to learn physics. This research used the quasi-experimental pretest-posttest design. The sample of this research consisted of two tenth-grade science classes chosen by simple random sampling technique. This research population was all tenth-grade students of a senior high school in Yogyakarta. The data were obtained by test and non-test techniques. The result shows that BBL approach affects on the students' higher-order thinking skills (sig. 2-tailed = 0,003 < α = 0.05). Further, it also improves students' higher-order thinking skills represented by the N-Gain value (experimental class N-Gain = 0.40 > control class N-Gain = 0.21). On the other hand, not only on student's higher-order thinking skills, BBL approach bring the significant effect on students' motivation in learning physics (sig. 2-tailed = 0,000 < α = 0.05) as well as could improve it (experimental class N-Gain = 0.55 > control class N-Gain = 0.04). It means that the BBL approach could improve higher-order thinking skills and students' motivation more effectively than the traditional approach.

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INTRODUCTION

Physics learning emphasizes the mastery of concepts and practicing creative, innovative, and critical thinking (Wartono et al., 2019). Furthermore, thinking ability and students' attitudes and motivation are also important (Putra et al., 2018). One of the main factors in the learning process is how teachers deliver the knowledge to the students (Bunyamin, 2016; Dare et al., 2018; Fariyani et al., 2020). Introducing the students to the next level of thinking skill could help them overcome their problems (Pamungkas et al., 2018). Moreover, students' understanding can be achieved by an active thinking process and various learning experiences (Rahmawati et al., 2020; Shernoff et al., 2017). Meanwhile, collaborating digital and conventional media

is also essential to support students' thinking skills (Kurniawan et al., 2019; Mastuang et al., 2020). Generally, there are two kinds of thinking skills, lower-order thinking skills (LOTS) and higher-order thinking skills (HOTS) (Wartono et al., 2018). LOTS or essential thinking skill only requires the students to remember, understand and apply a formula or law, whereas HOTS is more than those. Facilitating HOTS itself is necessary since challenge and the higher-level study problem can improve the learning process (Ramakrishnan, 2018). The 4.0 industrial revolution era requires a learning context to train and make the students have a good capacity and ability on autonomous, collaboration, and good time management in fulfilling the demands of the 21st-century industry. Higher-Order

Thinking Skills (HOTS) should be implemented in schools to allow the students to apply, analyze, evaluate and think creatively. On the other term, HOTS could be defined as transferring, critical thinking, and problem-solving skill (Kaur, Singh, & Marappan, 2020).

Unfortunately, the student's understanding, especially for HOTS, is still low. As an instance, it can be shown by the results of a preliminary study at one favorite senior high school in Yogyakarta. This preliminary study was conducted by analyzing the students' test results, observing the learning process, and interviewing the physics teachers and several students.

As a result, in the academic year of 2018/2019, there were only 81 out of 216 students (38%) of Mathematics and Natural Science class who met the minimum score. Theoretically, since it was less than 65%, the learning process should be re-conducted in those classes. Furthermore, the percentage of C4, C5, and C6 questions level is still low. As a consequence, the students will lack HOTS ability. Among all topics in Physics, temperature and heat topic showed the lowest percentage of 3.3%. This result can be caused by the learning process that is still teacher-center and did not facilitate their higher-level thinking skills. Moreover, learning media is also essential to support problem-solving skills and learning achievements (Labibah et al., 2019; Mulhayatiah et al., 2019).

As a result, only a few students that actively involved in the learning process. This traditional technique affects students' conceptual understanding and lowers students' motivation to learn physics (Khalid et al., 2012). The students do not have enough spirit to involve with the learning process since it looks dull and unchallenging. This situation makes them do not enjoy the learning process since they the only teacher that being active and the center of study. Some approaches such as project-based learning, cooperative learning, and

inquiry-based learning have been proposed (Mukti et al., 2020; Rahayu et al., 2017; Wartono et al., 2018).

On the other hand, due to its concept that follows how the brain works, the Brain-Based Learning (BBL) approach is currently happening. This approach is aligned with how the brain works as designed naturally (Jensen, 2008). As reported by prior studies, BBL could help to improve the speaking skills and meta-analysis ability of the students.

Talking about the benefits of brain-based learning is about changing how the teacher conducts the teaching process. More than that, it could change how to create all interpersonal communication, especially when conveying information is the goal of communication. Hence, this approach could facilitate the teacher to make more intelligent and more purposeful teaching to a more significant number of students through better engagement, higher achievement, and stronger retention (Gözüyeşil et al., 2014; Khalil et al., 2019). Furthermore, the Brain-Based Learning (BBL) approach could facilitate the formation of some intelligence such as kinesthetic, interpersonal, intrapersonal, logical, musical, naturalist, verbal and visual (Yagcioglu, 2014). In social studies, BBL can also be applied in natural science as conducted by previous studies (Mekarina et al., 2017; Saleh et al., 2019).

The pre-exposure, preparation, incubation, and memory entry stages and celebrations and integration in the BBL approach are expected to solve students' low learning motivation (Akyurek et al., 2013; Tüfekçi et al., 2009). Meanwhile, the initiation and acquisition stages and the elaboration stage are expected to be able to facilitate students in practicing higher-order thinking skills.

Nevertheless, the previous study just focused on student's motivation and their attitude in the class. As a compliment, the researchers in this research are interested in applying the Brain-Based Learning (BBL)

approach to temperature and heat topics which is expected to improve students' higher-order thinking skills and motivation in learning physics since it has not been conducted yet by the previous study.

Moreover, this research combined two different parameters, both HOTS study result and motivation, by specifying the activity that could facilitate students' ability improvement based on how the human brain works naturally. It makes this research different from the previous one.

METHOD

This research combines the quasi-experimental approach with a pretest-posttest control group design. The variables in this research are the Brain-Based Learning (BBL) approach, students' higher-order thinking skills, and physics learning motivation as the independent variable and dependent variable, respectively. The populations of this research were all tenth-grade science students of a senior high school in Yogyakarta in the 2018/2019 academic year. A simple random sampling technique was applied in class X MIPA 5 as the experimental class and class X MIPA 6 as the control class. The students in the control group were treated by the traditional method, where the learning process is dominated by the teacher as the center of the study. This method is the standard method that is applied in most of the classes. The flowchart of the research can be seen in figure 1,

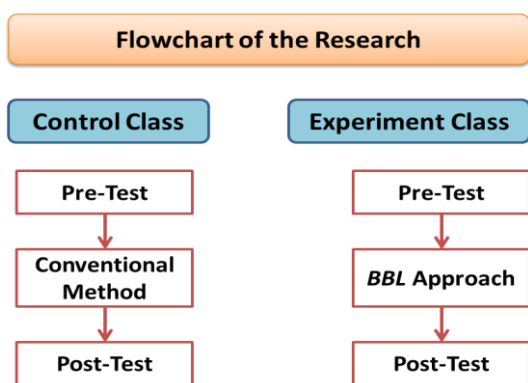


Figure 1. The Flowchart of the Research

Prerequisite tests were carried out to determine the next step related to the statistical operations to be performed. Parametric statistics were used in this research since the data were normally distributed. Data processing was performed using SPSS 16.0.

The data was collected through tests and non-test. The pretest-posttest question sheet of students' higher-order thinking skills consisted of 8 questions. Also, a questionnaire of students' physics learning motivation that consisted of 22 questions was prepared as the research instrument. The pretest questions aim to measure students' initial abilities in the experimental and control class before the treatment is given. The posttest questions aim to measure students' ability in the experimental and control class after the treatment is given.

The questionnaire sheet in this research was used to find out students' physics learning motivation. This questionnaire sheet was given to the experimental and control class before and after the treatment was given.

This instrument uses a Likert scale in the form of a checklist. The questionnaire was grouped into favorable items (containing positive values) and unfavorable items (containing negative values) to minimize the inconsistencies of students' answers. Scoring for each different statement was classified as presented in table 1.

Table 1. Guidelines to Scoring the Questionnaire of Students' Learning Motivation.

Score (favorable)	Category	Score (unfavorable)
4	SS (Strongly Agree)	1
3	S (Agree)	2
2	KS (Less Agree)	3
1	TS (Disagree)	4

A test is valid if the test can measure what it should measure (Arikunto, 2012). The test validity in this research includes logical and empirical validity. The instruments were consulted to the experts in

pretest questions, posttest questions, students' physics learning motivation questionnaire, and lesson plans. At the same time, empirical validity was obtained by conducting trials on students. The data were then analyzed to determine the value of product-moment correlation and reliability. The validity of the description form was examined using Product Moment correlation.

In this research, only the items with a correlation coefficient higher than 0,600 were categorized as high and very high validity.

The determination of the items used in this research was based on the logical validation from the experts and the empirical validation of the test problems on students. The items used were valuable items according to the experts and have met predetermined criteria. If items do not meet one of the predetermined criteria, the questions were dropped or rejected. After getting valid things, the questions were tested for their reliability. The reliability of the instrument was tested using the Alfa Cronbach formula.

The next step was data analysis. First, the normality test using the Kolmogorov-Smirnov assisted by SPSS 16.0 and the homogeneity test using Levene test were conducted. After the prerequisite tests were conducted, the next hypothesis test was performed. The hypothesis was examined through a t-test to find differences in each class after treatment. Meanwhile, to figure out its improvement, an N-gain equation was elaborated. The normalized N-gain classification according to Richard R. Hake is described in table 2 (Hake, 1998):

Table 2. N-gain Classification

Average of N-gain	Classification
$N\text{-gain} \leq 0,30$	Low
$0,30 < N\text{-gain} \leq 0,70$	Medium
$0,70 < N\text{-gain} \leq 1,00$	High

RESULTS AND DISCUSSION

The Data of Test Instrument Trial

Before the test instrument was used, the test instrument was validated by the expert. The logical validation outputs were in the form of inputs and suggestions. These data were used as a reference in the revision of the following test instrument. Of the thirteen items, nine items were valid, and four things had to be revised. After revision, the thirteen questions were tested on 30 students to find out their empirical validity.

Based on the product-moment correlation test results, eight valuable items were obtained and used in this research. Those items are number 1, 2, 3, and 7 in Type A, and item number 1, 2, 3, and 4 in Type B. Invalid question items were not used in data collection.

The eight valid questions were then tested for reliability using SPSS 16.0. Cronbach's Alpha value was obtained at 0.596 based on the results of the reliability test. This value is more significant than 0.5, which indicates that the test instrument is reliable. There are two kinds of data in this research: data on students' higher-order thinking skills and physics learning motivation. Data on students' higher-order thinking skills were obtained through tests in questions and descriptions, while data on students' physics learning motivation were obtained through motivation questionnaire sheets. Moreover, the level of difficulty and the different power of the questions are shown below.

Table 3. Level of Difficulty and the Discrimination Index of the questions

Question	Level of difficulty	Different power
1	Medium	Enough
2	Hard	Enough
3	Hard	Good
4	Hard	Enough
5	Hard	Bad
6	Medium	Bad
7	Medium	Enough
8	Hard	Enough

Data of Research Results

The average pretest scores of the experimental and control classes students' high-order thinking skills (HOTS) are 29.38 and 30.75, respectively. The score was then analyzed using a two-tailed t-test. Based on the analysis, there was no pretest average score difference between each class.

After the treatment was given, the average score tended to increase for both classes. The average posttest scores of the experimental class and the control class are 57.62 and 45.59, respectively. The scores were then analyzed using a two-tailed t-test. The results show that there are differences between experimental and control class posttest average score.

The pretest and posttest average scores of students' HOTS of both classes are presented in the following graph. Average score of students' higher-order thinking skills can be seen in figure 2,

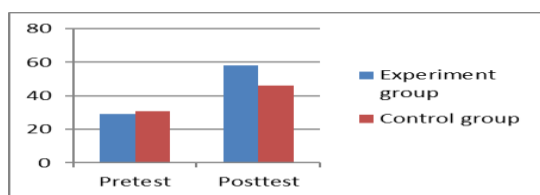


Figure 2. Average Score of Students' Higher-Order Thinking Skills

The experimental class N-Gain value is 0.40 (medium), while the control class N-Gain value is only 0.21 (low). The experimental class HOTS improvement is more significant than that of the class control.

In this research, seven HOTS indicators are used: distinguishing relevant information, organizing and integrating, relating some point of views, criticizing, generalizing hypothesis, problem-solving, and creating a product. The N-Gain value of each HOTS indicator is shown in Figure 3,

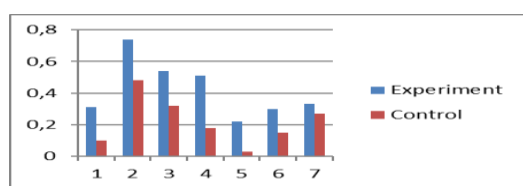


Figure 3. N-Gain Value of Each HOTS Indicator

The following table 4 is an example of the student's answer on the HOTS concept in daily life.

Table 4. The Question and Answer

Question
<p>Jawablah pertanyaan-pertanyaan di bawah ini dengan jelas!</p> <p>1. Ketika Andi berkemah di kawasan Puncak Bogor, Andi merasakan dinginnya udara yang menusuk hingga ke tulang. Andi pun memutuskan untuk mengambil jaket dan memakainya. Setelah memakai jaket, Andi merasa lebih hangat.</p> <p>a. Jelaskan bagaimana cara kerja jaket sehingga membuat Andi hangat!</p> <p>b. Apa yang terjadi jika Andi melepaskan jaketnya? Jelaskan alasannya!</p>
Student's Answer in Control class
<p>a. Karena jaket merupakan isolator yang dapat menghambat udara masuk ke dalam pori-pori. Jaket bergerak dengan kulit sehingga menahan panas yang dapat menghantarkan tubuh. b. Akan kedinginan. Karena tidak ada yang bergerak dengan kulit, sehingga tidak menghantarkan panas.</p>
Student's Answer in Experiment class
<p>a. Jaket dapat menjadi isolator panas sehingga panas terperangkap dalam jaket. Panas tubuh yang keluar terperangkap dalam jaket sehingga terasa hangat.</p> <p>b. Andi merasa kedinginan, karena panas akan langsung beresap dengan udara luar dengan cara lebih rendah sehingga Andi merasa kedinginan.</p>

From table 4, it can be seen that the student in the experiment class that was treated by the BBL approach can answer the question correctly compared to the student in the control class that was treated by the conventional method. This question looks simple but needs a deep understanding of the temperature and heat concept.

As we all know, the heat will flow from the higher to the lower temperature. So, in this case, the jacket can help Andi to keep himself warm because the jacket can prevent the heat from his body from going out and meet the temperature equilibrium with the air temperature outside that cooler than his body, as stated by the student in experiment class. Meanwhile, the student in control class still have the misconception by assuming that the jacket can prevent the cooler temperature of the air to entrance Andi's body. This question related to the analysis ability of the students, where they were asked to organize and integrate the information or the phenomena that they get to create a structure of the knowledge.

In contrast, the questionnaire sheets of student physics learning motivation were given before the first and the last meeting. Then, the score before the experimental and control class treatment was 60.73 and 59.3,

respectively, and then analyzed using a two-tailed t-test. So, it is known that there is no difference in learning motivation for both classes before the treatment.

After treatment, the measured learning motivation tended to increase to 82.39 and 60.70, respectively. The score is then analyzed using the two-party t-test. The results are shown in the following graphs.

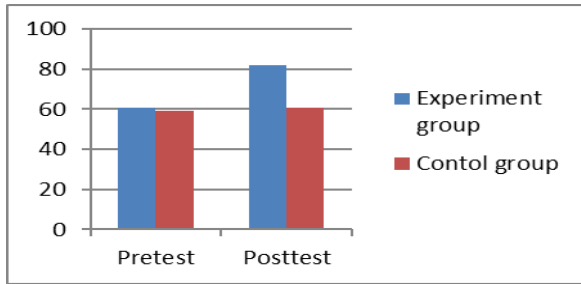


Figure 4. Average Score of Students' Physics Learning Motivation

There are four motivation indicators that used in this research, desire of studying; reward on learning process; exciting activity, and conducive environment. The N-Gain value of each motivation indicator is shown in Figure 5,

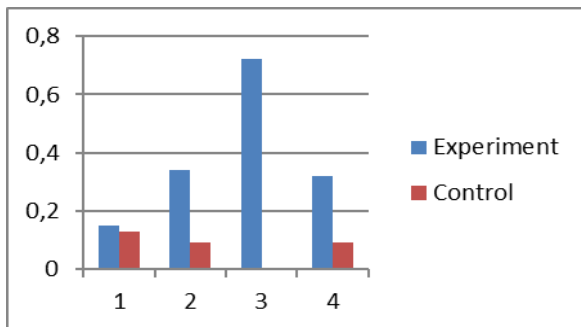


Figure 5. N-Gain Value of Each Motivation Indicator

After comparing the average scores of motivation questionnaire before and after the treatment of both classes, the analysis of N-Gain test was continued. As a result, the experimental class N-Gain value was 0.55 (medium), while the control class N-Gain value was 0.04 (low).

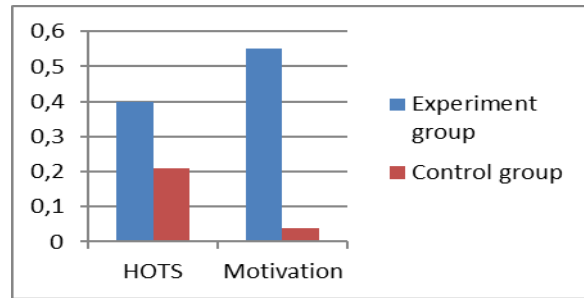


Figure 6. N-Gain Value of Students' Higher-Order Thinking Skills and Physics Learning Motivation

This means that there are differences in the N-Gain category between the experimental and the control class. An increase in thinking skills at a high level in the experimental class is more significant than in the control class. Figure 6 shows the N-Gain values, students' higher-order thinking skills, and the experimental and control class's physics learning motivation.

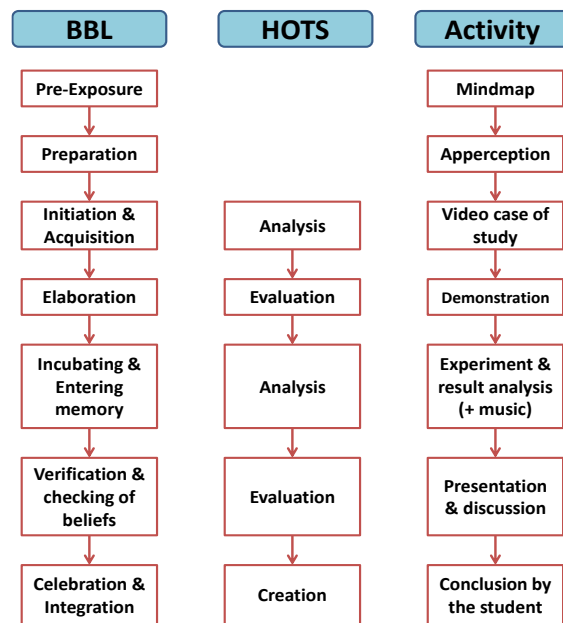


Figure 7. The Steps of BBL in Facilitating HOTS

This improvement in students' learning achievements and motivation can be associated with the learning process of BBL. Figure 7 shows the learning process of BBL that can facilitate the improvement of HOTS.

Normality Test

The Kolmogorov-Smirnov test observed the normality of students' HOTS and physics learning motivation questionnaire. The conclusion was decided according to the measured significance value and (α) significance level equal to 0.05.

As a result, the experimental and control class sig value are 0,400 and 0,499. Since they are greater than (α) 0.05, it can be assumed that the HOTS pretest was normally distributed.

Moreover, the experimental and control classes' sig. value were 0.790 and 0.051, respectively. So, it is clear that HOTS posttest data were normally distributed.

Further, the learning motivation data were normally distributed since both experiment and control class showed a higher value than 0.05, which are 0.128 and 0.635 for pretest and 0.277 and 0.379 for posttest. Thus, the statistics used in data analysis are parametric in the form of t-tests.

Homogeneity Test

The homogeneity was tested using the Levene test. It is concluded that the

homogeneity test results of the data seen based on the significant value of the calculation results compared with the significance level (α) are 0.05.

The obtained Levene value was 0.017, which was less than 0.05. It indicated that the data were not homogeneous. Hence, students' HOTS in both classes before treatment was not the same. On the other hand, the HOTS posttest Levene test indicates the opposite result with a value of 0.456 that much bigger than 0.05.

For the learning motivation, the pretest result shows a Levene value of 0.644, while posttest results shows only 0.006. So that the learning motivation before treatment is homogeneous while the motivation after treatment is not.

Hypotheses Test

The first hypothesis test is to find out the effect of treatment on HOTS of the experimental class. The data were analyzed by an independent t-test assisted by SPSS 16.0.

Table 5. Independent t-test Results of Students' Higher-Order Thinking skills

Section	Class	N	t-value	df	Sig.(2-tailed)	α	Note
Pretest	Experiment	34	-0.539	54.343	0.592	0.05	Not different
	Control	34					
Posttest	Experiment	34	3.090	66	0.003	0.05	Diffeent
	Control	34					

Students' initial ability is reflected in the pretest scores obtained before the two groups were given the treatment. The sig evaluated the pretest scores. (2-tailed) and then compared to (sig. α) of 0.05. Based on the result presented in table 5, the value of sig. (2-tailed) is 0.592 that is bigger than α . So, it can be stated that the students have the same initial ability. Hence, Ho was supposed to be accepted, and Ha was rejected.

Meanwhile, the HOTS posttest results show the different outcomes. According to

the measurements presented in Table 5, the sig (2-tailed) is only 0.003 that less than α . Hence, BBL affects student's HOTS, Ho was rejected, and Ha was accepted.

The second hypothesis test is to determine the treatment effect on the learning motivation of the experimental class. According to the result in table 6, the sig. (2-tailed) value is 0.201, bigger than α . So, it indicates it is no difference between students' initial motivation of both classes before treatment. Then, Ho was accepted, and Ha was rejected.

For the posttest, the sig. (2-tailed) value is 0,000 that less than α of 0.05. So it can be concluded that H_0 is rejected and H_a is accepted. Hence, the Brain-Based Learning

approach affects students' physics learning motivation on temperature and heat topics. Here is the t-test independent data on students' motivation.

Table 6. Independent t-test Results of Students' Physics Learning Motivation Data Questionnaire

Section	Class	N	t-value	df	Sig. (2-tailed)	α	Note
Pretest	Experiment	34	1.291	66	0.201	0.05	Not different
	Control	34					
Posttest	Experiment	34	18.416	59.67	0.000	0.05	Different
	Control	34					

The third hypothesis test is to figure out the improvement of HOTS that the N-Gain value can see of pretest and posttest scores of the experimental and the control class. According to Table 7, the experimental class N-Gain value is 0.40 (medium), while the

control class N-Gain value was only 0,21 (low). So, it can be seen that BBL could improve students' HOTS on temperature and heat. The complete analysis results are presented in Table 7.

Table 7. N-Gain Test Results of Students' Higher Order Thinking Skills

Class	N	Ave-rage Score Post-test	Ave-rage Score Pretest	N-Gain	Classification
Experimental	34	57,62	29,38	0,40	Medi-um
Control	34	45,59	30,75	0,21	Low

Further, the fourth hypothesis test analyzes the improvement of students' physics learning motivation.

From table 8, it can be seen clearly that experimental class N-Gain is 0.55 (medium), bigger than that of the control

class of 0.04 (low). Then, the learning process using the BBL approach could improve students' physics learning motivation on temperature and heat topics, as shown in table 8.

Table 8. N-Gain Test Results of Questionnaire Data of Students' Physics Learning Motivation Questionnaire

Class	N	Ave-rage Score Post-test	Ave-rage Score Pretest	N-Gain	Classification
Experimental	34	82,39	60,73	0,55	Medi-um
Control	34	60,70	59,3	0,04	Low

In general, the treatment given to the experimental class provides an increase in high-level thinking skills of students in the medium category for almost all indicators of higher-order thinking skills. Furthermore, generally, the training given to the experimental class provides an increase in students' physics learning motivation in the medium category for almost all indicators of learning motivation.

This improvement in both HOTS and student's learning motivation can be associated with the steps that have been conducted based on the BBL approach. As shown in figure 5, each step of the BBL approach can facilitate the HOTS indicators. For example, analysis activity can be built by the initiation and acquisition step. In this step, the student can be the initiator to face and observe the phenomena presented in the

video. If the teacher explains everything about this phenomenon in the conventional system, the student just listens to it. Still, the video presentation shown by teacher can stimulate the student to observe it by themselves and try to analyze what is going on.

Furthermore, to confirm the student's understanding, the teacher facilitates the students to do some demonstrations or experiments by themselves. This process can lead the student to think and reconfirm the basic knowledge that they have with the results that they get from the experiment. Hence, this activity could promote the increasing evaluation ability of the student.

After the student got a complete understanding of the phenomena, they can be actively forced to find and create another different example and conclude the whole idea as the highest level of thinking.

These different BBL approaches will finally lead to the different results of the study compared to other systems or learning methods. Hence, better students' ability in both HOTS and learning motivation can be achieved.

The motivation improvement can also be a sign that the BBL approach based on how the brain works naturally effectively increases student's awareness of learning compared to the conventional method before the treatment was given.

The results of this research confirm and support the previous work about the effectiveness of the BBL approach towards student achievements. As previously reported, the BBL approach could also improve the student's retention on the higher level of learning facilitated by meaningful activities through the BBL approach learning environment (Tüfekçi et al., 2009). This learning process can be accepted very well by the students since it fits their preferences and is organized very well by creating democratic and active students' active contributions during the learning process.

Specifically, there are three leading indicators of HOTS that can be facilitated by some learning steps in the BBL approach. For an instance, the initiation and acquisition step of BBL, the analysis ability of the student could be facilitated by video case of study activity. Moreover, the experiment process also could strengthen the analysis ability of the student. In this process, the student are force to think what do they find and observe during experiment. They also need to analyze the physical phenomena beyond it.

Furthermore, the next level of HOTS is evaluation. This ability can be formed by the presentation and discussion activity on verification and checking of beliefs steps of BBL. After the student observe the phenomena by doing experiment, the student were asked to discuss and find the reason why that phenomena happened. In this process, the student will compare what they saw on experimentation with the current theory. Hence, the evaluation ability can be created by this process.

This process finally leads the students to achieve the creation ability of HOTS. After the evaluation process, by discussing the experiment results and the theory, the student can finally conclude it. The student towards some inquiry process eventually found this conclusion. There are some BBL steps that make it different with the conventional method where the student listens to the teacher and get the decision from the teacher without involving the student during the process.

Furthermore, when the students were actively involved during the learning process, the student's motivation will be automatically increased. Fun and relaxed learning activities of the BBL approach can be triggers to boost the actual attendance, inspiration, and happiness of the students and physics conceptual understanding.

CONCLUSION AND SUGGESTION

Referring to the formulation of the problem and the results of research, some conclusions are drawn as follows: 1) learning by BBL approach affects students' HOTS on the topic of Temperature and Heat. This can be known through independent t-test which shows (sig. 2-tailed) significance level of 0.003 less than (α) 0.05; 2) learning using Brain-Based Learning (BBL) approach can improve students' higher-order thinking skills on the topic of Temperature and Heat. The experimental class N-Gain value was equal to 0.40 (moderate), which is greater than the control class N-Gain value of 0.21 (low); 3) learning using Brain-Based Learning (BBL) approach influences students' physics learning motivation on the topic of Temperature and Heat. The independent t-test shows the significance level (sig. 2-tailed) 0,000, which is smaller than the significance level (α) 0.05; 4) learning using the Brain-Based Learning (BBL) approach can increase students' physics learning motivation on the topic of temperature and heat. This can be seen through the N-Gain value of the experimental class of 0.55 (moderate) which is greater than the N-Gain control class of 0.04 (low).

After conducting research, data analysis and discussion, the researchers give some suggestions: 1) Physics teachers are recommended to use Brain-Based Learning (BBL) approach as an alternative to improving students' higher-order thinking skills on cognitive aspects and physics learning motivation; 2) Physics teachers are suggested to make assignment questions in line with the indicators of higher-order thinking skills (HOTS) cognitive aspects based on Bloom's taxonomy, at the level of analyzing, evaluating and creating as a means to practice high level thinking skills of students; 3) further researchers are suggested to conduct research using Brain-Based Learning (BBL) approach in term of other variables besides the cognitive aspects

of higher-order thinking skills and students' physics learning motivation.

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