Enhancing students' mathematical connection by brain based learning model

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Abstract. Students’ mathematical connection is one of ability that students must have. However, one of the reasons that student’s mathematical connection is still poor is the lack of enthusiasm of students while learning mathematics, and learning that does not give flexibility to students to empower the brain. Therefore, it is necessary to have an alternative learning that can develop students’ mathematical connection. The purpose of this study is to find out students’ enhancement in mathematical connecting ability who worked under brain-based learning model and students’ who worked under expository learning model and the effect of brain based learning model on enhancing mathematical connection ability. This study used a quasi-experimental method. The subject in this research was 49 students from 2 classes in one of junior high schools, in Subang, West Java, selected by applying purposive sampling technique. The instruments used were mathematical connection test and attitude scale. Based on the results it was concluded that: (1) students’ enhancement in mathematical connecting ability who worked under brain-based learning model is higher than that of students’ who worked under expository learning model; and (2) the students’ who worked under brain-based learning model showed positive attitude toward mathematics lesson.

Keywords: mathematical connection, brain-based learning.

1. Introduction

In mathematics learning, one material is a prerequisite for other material, or one concept is needed to explain the other concepts. In this case, students are expected to have the ability to solve problems - mathematical problems that have relevance to the material previously studied. This ability is called mathematical connection ability [6].

NCTM [8] revealed that one of the mathematical abilities that need to be mastered and developed is mathematical connection ability. Mathematical connection ability is the ability to associate concepts or procedures contained in mathematics with mathematics itself, with other fields of science and with everyday life [12].

Through mathematical connections, students' insights will be more open to mathematics, which will then lead to a positive attitude towards mathematics itself. Through the process of mathematical connection, the concept of thinking and students' insight into mathematics will be even wider, not only focused on the topic being studied [3].
Mathematical connection ability needs to be owned by students, but according to Musriliani [7] and Widyawati [16] the mathematical connection ability of junior high school students is still low. The reason of mathematical connection ability is still low is because students are not accustomed to working on connection problems between mathematical topics and connections with the real world and rarely get it in learning. Therefore, enhanced mathematical connection ability in learning mathematics is very important.

These conditions require teachers to change the views of the learning model that has been applied so far. Effective learning is learning that is able to balance all potential thinking of students. In other words, effective learning is learning that is able to balance the potential of the right brain and students' left brain. If learning in the classroom does not involve both brain functions, there will be cognitive imbalance in students, namely the potential of one part of the brain will be weakened due to the non-use of the function of the brain.

Based on the description above, students’ need learning that can optimize the work of the brain and is expected to improve students' mathematical connection ability. The right learning model with these characteristics is brain-based learning model. Brain-based learning model is a learning that is formed or used to balance the way the brain works [1].

Similar to Jensen opinion, Lestari and Yudhanegara said that brain-based learning model is scientifically designed for learning, not focused on sequencing, but prioritizes the enjoyment and love of students to learn, so students can easily absorb the material being studied [5].

In brain-based learning, students are required to be active in finding their knowledge about the topic being studied. This is based on the cognitive structure it has and is based on the way the brain works. The brain is easier to absorb new information that is presented attractively, uses a variety of colors and what is not less important is the environmental conditions when absorbing that information [14].

In brain-based learning model there are three strategies that can be developed, namely: (1) creating a learning environment that challenges students' thinking abilities; (2) creating a pleasant learning environment; (3) creating active and meaningful learning situations for students [13]. These strategies provide opportunities for students to hone thinking skills, especially mathematical connection skills [5].

The process of creating connections in mathematics learning can be done through brain-based learning model, considering that in brain-based learning model there are stages of initiation and acquisition. According to Jensen [1], the initiation and acquisition stage is the stage of creating a connection or when neurons "communicate" with each other. Thus, it can be concluded that the more connected neuronal networks, the more it stimulates students' thinking abilities, which in turn will increase the meaning that students get from learning. Varied math assignments, can train students to use and develop mathematical connections. In addition, a pleasant learning environment will also motivate students to actively participate and perform activities optimally in learning.

2. Method
The research method used was quasi experiment with non-equivalent control group design. In the experimental group is given learning with brain-based learning model to improve students' mathematical connections. The subjects of this study are 49 students of grade 8 of a Junior High School that was determined purposively. The subject of the research was grouped into 2 different groups. The first group was treated under brain-based learning model while the second group was given expository learning model.

There are seven phases or stages of the brain-based learning model according to Jensen [1], namely Stage 1. The pre-exposure, this stage provides a brain review of new learning before actually digging further. Pre-exposure helps the brain develop better conceptual maps and prepare concentration to be ready for learning. Things that can be done: a) The teacher shows a concept map of the material to be studied, b) The teacher conditions an interesting learning environment, c) Submission of learning objectives, and d) Students are asked to bring drinking water / minerals as brain nutrition.

Stage 2. Preparation, at this stage, the teacher creates curiosity and pleasure in students. There are: a) Students are given an initial explanation of the material to be studied and b) Students are
encouraged to respond to whether or not the material is relevant to what is in real life initiation and painting, elaboration, incubation and insertion of memory, verification and checking of beliefs, and celebration and integration.

Stage 3. Initiation and acquisition, this stage is the stage of creation of understanding, connection or when the neurons "communicate" with each other. Things that can be done are: a) Presenting material with the help of audio-visual media for example using power point and b) Start active learning e.g. by guiding students into discussions on group assignments, filling out Student Worksheets to rediscover concepts.

Stage 4. Elaboration stage, this stage provides an opportunity for the brain to sort, investigate, analyze, test, and deepen the lesson. Things that can be done: a) Students present the results of the discussion in groups or in front of the class, b) Conduct open questions and answers about the results of the discussion or the material being studied, and c) Students are asked to make individual or group concept maps of what they have learned.

Stage 5. Incubation and insertion of memory, this stage emphasizes the importance of rest and time to repeat. Things that can be done: a) Students with teachers do stretching and relaxation for example doing brain gymnastic movements (Brain Gym), b) Students are given a video watch that can train concentration and focus on the brain, and c) The teacher provides practice questions.

Stage 6. Verification and checking of beliefs, in this stage, the teacher checks whether the students understand the material that has been learned or not. Things that can be done: a) The teacher checks whether students understand or not with the material that has been learned and b) The teacher holds quizzes for students both verbally and in writing.

Stage 7. Stage of celebration and integration, this stage instills all the important meanings of the love of learning. Things that can be done: a) Give awards to students, b) When sharing or telling stories of exciting experiences, and c) In closing, teachers and students carry out small celebrations such as cheering and clapping.

The instruments used in this research were mathematical connection test and attitude scale. Indicators which covered in the test are: 1) the connection between mathematical topics, 2) connections between mathematical topics and other fields of study, and 3) connections between mathematical topics and daily life.

3. Result and Discussion

Table 1 shows the results data in this research about students’ mathematical connecting ability. In the following table it is clear that the average of mathematical connecting score is 5.48 with the standard deviation 0.65; while the control group has the average of 5.67 with standard deviation 1.31.

| Test Result | Experiment Group | Control Group |
|-------------|------------------|---------------|
|             | Min   | Max  | Ave  | SD | Min   | Max  | Ave  | SD |
| Pre-test    | 4     | 7    | 5.48 | 0.65 | 3     | 7    | 5.67 | 1.31 |
| Post-test   | 11    | 23   | 18.28 | 3.43 | 9     | 20   | 15.62 | 2.96 |
| N-gain      | 0.32  | 0.94 | 0.69 | 0.18 | 0.29  | 0.76 | 0.55 | 0.14 |

Note: Ideal Maximal Score = 24

Both pre-test results are relatively equal, showing relatively small difference (not higher than 0.19). This result indicates that initially the competency of the two groups was relatively equal. The distribution of the data is relatively equal. This can be observed from the table, where the standard deviation of both pre-tests is relatively equal (the difference does not exceed 0.66). The students from
The experiment group reached mathematical connecting score of 18.28 after brain-based learning model was implemented, whereas the students from expository learning group reached 15.62 (with the ideal maximal score 24). This difference is significantly high, which means that brain-based learning model contributes mathematical enhancement to the students. This is in line with the result of previous experiments conducted by [2, 9-11, 15], which indicated that brain-based learning model could enhance students’ mathematical connecting ability.

The data of normalized gain shows that the students’ enhancement in mathematical connecting ability under brain-based learning model is 0.69 (middle level), compared to expository learning group which reached 0.55 (middle level). Although, both gains are in the same level, the first enhancement, however, shows better result. The middle level of normalized gain which the students’ have shown that their competence in mathematical connecting still needs further enhancement.

From table 1, it is known that there are differences in the average results of the mathematical connection ability test between experimental and control group, which shows that mathematical connection ability in class using the brain-based learning model is higher than the class that uses expository models. This did not happen by accident, but because of the different stages of learning between the two classes.

Jensen [1] argues that brain-based learning is not focused on sequencing, but prioritizes the enjoyment and love of students to learn, so students can easily absorb the material. This learning model considers what is natural for the brain and how the brain is affected by the environment and experience. This learning model also does not require or instruct students to learn, but stimulates and motivates students to learn by themselves.

Jensen [1] suggests that brain-based learning model contains seven stages of learning in the classroom that have also been carried out by researchers including pre-exposure, preparation, initiation and acquisition, elaboration, incubation and insertion of memory, verification and checking of beliefs, and celebration and integration.

3.1. Pre-exposure stage

This stage provides a brain review of new learning before actually digging further. The teacher shows a concept map of the new material to be studied. From the presentation of the concept map many students respond positively to various questions so that there is an interaction between the teacher and students that makes students comfortable without fear of the difficulty of mathematics since learning begins. Next the teacher conveys the learning objectives that will be implemented. At this stage the teacher also advises students to bring drinking water as an energy supply in learning.

3.2. Preparation stage

At this stage, the teacher gives an initial explanation of the material to be studied. Students are encouraged to respond to and know the material about relationships and functions and respond to the relevance of the material to what is in everyday life. From what is seen in class, the curiosity and enthusiasm of students increases to learn more about the material that will be delivered.

3.3. Stage of initiation and acquisition

At this stage the teacher asks students to form groups consisting of 4 students per group by giving students the freedom to choose their own seats and groups. Then each group is given a student worksheet to discuss with the group members. Each meeting is given a different student worksheet to rediscover the concepts and formulas of relations and functions. Based on the results of observations, in the first meeting students were still confused when filling in the student worksheet, each group often asked the teacher how the intentions and ways of filling in the steps in the student worksheet. However, this is very reasonable because they are the first time doing such learning activities. At the next meeting students are seen to have begun to understand and understand what must be done so that learning activities at this stage run smoothly.

3.4. Elaboration stage

At this stage students from the group representatives present the results of the discussion in front of the class, while the other students pay attention, correct, respond, and ask so that students can find the right answers to the problems in the worksheet. In its implementation, some students still feel embarrassed to come to the front of the class. To solve this problem, the teacher gives rewards in the form of giving ballpoint pens to students who dare to come forward to present the results of their
discussion. This is done so that at each meeting there are different students to come forward and present the results of the discussion.

3.5. Stage incubation and insertion of memory

This stage is a break between lessons. Resting here does not mean staying silent, but resting from brain-draining activities. This incubation stage is filled with brain gym (brain gymnastics) by doing light movements that serve to stretch the muscles after learning, reduce stress, and increase the concentration of learning. In addition to doing a brain gym, in some meetings this stage is also filled with watching motivational video shows accompanied by instrumental music that can make the brain relax and ready to receive the next lesson again.

From the results of observations, it seems that students feel happy doing these things. After the wickedness period is over, the teacher gives practice questions to students to test the extent to which students are able to apply a concept and formula that they have found at the stage of initiation and acquisition.

![Students Doing Brain Gym Movement](image1.jpg)

**Figure 1.** Students Doing Brain Gym Movement

3.6. Stage of verification and checking of beliefs

At this stage, the teacher gives more complex questions to train students' understanding in linking between mathematical concepts, both between mathematical topics and with everyday life. The teacher guides and ensures students have understood and understood the material at each meeting.

3.7. Celebration and integration stages

At this stage with the guidance of the teacher the students are directed to be able to conclude the things they have learned. Next the teacher tells the students about the material to be learned at the next meeting. In closing, teachers and students carry out small celebrations such as cheering and clapping.

Based on the description above, we can see that mathematical connection ability of the experimental class students is better than control class students, it can be concluded that the brain-based learning model has a positive influence on enhancing students' mathematical connection ability. This is also indicated by the results of the calculation of the effect size obtained by the ES value (d) of 0.89. Because the ES (d) value > 0.8, based on the Cohen’s effect size value, the value is included in the big criteria. Therefore, it can be concluded that the brain-based learning model has a large influence on enhancing mathematical connection ability of middle school students.

Indicators of mathematical connection ability in this study are: 1) the connection between mathematical topics, 2) connections between mathematical topics and other fields of study, and 3) connections between mathematical topics and daily life.

Indicator I: Connection between Mathematical Topics

The answer of the figure 2, it can be seen that the experimental group students can answer or solve the problem better than the control group students. In general, the experimental group students were able to write domain members, codomains, and range of functions in a structured manner and were able to connect the concepts of sets and correctly understand inequality symbols in mathematics. While the answers given by the control group students, although in general it has shown the correct understanding of the concept, but the answers outlined are incomplete. In addition, the calculations performed are correct but the final answer is incorrect.
Figure 2. Result of Students Answer for Number 2

Figure 3. Result of Students Answer for Number 4

Indicator 2: Mathematical Connections with Other Fields of Study

Figures 3 above show that the answers to the experimental group students are correct and complete, while the control group students' answers are correct but incomplete. This is because the control group students are accustomed to direct answers without understanding the questions given so that there are conceptual errors in the answers to the control group students above.

Indicator 3: Mathematical Connections with Daily Life

The results of the answers in figure 4 show that the answers of students in the experimental group are more structured compared to the control group students. In presenting the concept in the form of mathematical representation, the experimental group students are correct and complete. Meanwhile in the answers of students in the control group cannot able to describe the questions into everyday life, so students cannot describe the situation in the problem. Even though the answers given by the control group students are correct, the method of solving the problem is incomplete. This shows that on this
third indicator the experimental group students can connect or associate problems related to daily life into mathematical concepts better than the control group.

Figure 4. Result of Students Answer for Number 6

As a general description of the results of research on students' mathematical connection ability in relations and functions with indicators between mathematical topics, connections between mathematical topics and other fields of study, and connections between mathematical topics and daily life in general the experimental group students showed better results than the control group students.

In terms of students' affective skills, it is obvious that the students’ who worked under brain-based learning model showed positive attitude toward mathematics lesson. The students’ who had been treated under brain-based learning model showed adequate interest, motivation, activity and understanding related to the importance of mathematical competency, compared to students’ in expository learning model group. After short period of time, the students’ enhancement of attitude is positive, although their improvements were not so high. The students’ attitude, apparently, will improve slightly after long period of time, if the students are given this treatment for a long period of time. It seems that this enhancement will not occur instantly after several weeks, no matter how intensive the treatment was.

4. Conclusion

Based on the result and discussion of the research, it can be concluded that: (1) students’ enhancement in mathematical connecting ability who worked under brain-based learning model is higher than that of students’ who worked under expository learning model; and (2) the students’ who worked under brain-based learning model showed positive attitude toward mathematics lesson. The students’ who had been treated under brain-based learning model showed positive enhancement of interest, motivation, activity and understanding related to the importance of mathematical competency, compared to the students’ who were given expository learning model. Long time period of treatment is expected to gain high enhancement in students’ attitude toward the above-mentioned aspects of attitude.

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