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*by* Tri Andari

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# Brain based learning to improve students' higher order thinking skills



# Brain based learning to improve students' higher order thinking skills

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**Abstract**. Higher-order thinking skills are an important component in the process of solving higher education problems that involve the mastery and understanding of scientific concepts. In an effort to hone students' thinking abilities, innovative efforts in learning are needed. The purpose of this study was to determine the increase in higher order thinking skills of students using brain-based learning. The research method used was quasi experimental with one group pre-test post-test design. Subjects used in this study were 54 students taken by purposive sampling. The instrument used in this study is a learning achievement test to measure higher order students' skills. The data analysis technique used is one sample t-test and N-Gain. The results showed the mean value of the pre-test was 57.65, the average value of the post-test was 70.41, and the average value of the N-Gain was 0.32. This shows that there is an increase in students' higher-order thinking skills by using brain-based learning in logic and set courses.

## 1. Background

The thinking ability is an important component in the problem solving process. The problem solving process involves mastering and understanding scientific concepts [1-3]. Mathematics is one scientific concept that aims to sharpen students' thinking abilities [4]. The existence of mathematics helps students in obtaining, selecting and managing information to solve problems and form thinking patterns [5]. These patterns of thinking can be developed through mathematics learning, because mathematics has a structure, strong and clear links between concepts [6]. The highest level of thinking is usually called Higher Order Thinking (HOTS).

The concept of HOTS comes from Bloom's Taxonomy. Bloom's taxonomic level includes knowledge, understanding, application, synthesis, and evaluation. The first and second levels of Bloom's taxonomy are considered low-level thinking abilities, while the other four levels are classified as HOTS [7,8]. According to [9,10] the higher order stages of thinking include applying, analyzing, evaluating and creating. [11] shows that HOTS influences student academic performance. HOTS occurs when a person gets new information and information stored in memory is interconnected, reorganized and extends this information to reach the goal or find possible answers in confusing situations [12]. HOTS are an important aspect in teaching and learning especially at higher education institutions [13].

Facts in the Mathematics Education Study Program of the University of PGRI Madiun, especially in the subjects of logic and set show that students are still in the stages of remembering and understanding,

this causes learning outcomes that are not optimal. Problems with unsatisfactory mathematics learning outcomes also occur in several places [14-16].

So far there has been no attempt to improve students' higher-order thinking skills on logic and set courses. One effort that will be made is to apply a brain-based learning model. The brain based learning model is a new learning paradigm in higher education [17]. Brain based learning models can facilitate students in learning optimization by using the overall function of the brain in students. The pattern of functional development of a person's brain is characterized by their maturity [18]. Based on this background, it will be proven whether the brain-based learning model can facilitate the improvement of students' higher-order thinking skills in logic and set courses.

## 2. Method

This research is a quasi-experimental research with one group pretest posttest design. According to [19] Quasi experiment research method is a study used to determine whether there is a result of "something" imposed on the subject under study by looking for the effect of certain treatments on others under controlled conditions. The stages to be carried out are pretest to see students 'initial high order thinking skills, treatment using brain-based learning, then posttest to see students' high order thinking skills after being given treatment.

This research was conducted at the Mathematics Education Study Program at PGRI Madiun University. The subjects in this study were 54 first semester students consisting of 2 classes. Subjects were taken using purposive sampling technique that is taking subjects using certain criteria to meet the requirements for use in research [20]. Consideration of taking subjects based on research development of teaching materials conducted using the 4D method which includes stages define, design, develop, and disseminate [21-23]. In this article only discusses the implementation phase of the set logic teaching material developed in the previous stage.

The instrument used by researchers was a learning achievement test. According to [24] a test is a tool or procedure used to find out or measure something in a way and rules that have been determined. The test discusses the material of logic and sets which in its solution involves proofing and reasoning theorems based indicators of high-level thinking ability with the object of knowledge including the conceptual, procedural, and metacognitive domains [25, 26]. Students' higher-order thinking skills are said to be improved if in solving a problem students not only show their ability in terms of knowing, understanding, and applying, but are also able to use high-level abilities such as analyzing, evaluating, and creating [26].

Data analysis techniques using the main data pretest and posttest. The data is analyzed to see the score of the test results which are then determined on average. Data analysis techniques used one sample t test and Normalized Gain (N-Gain). To calculate N-Gain, use a formula $Normalized\ Gain = \frac{S_{post}-S_{pre}}{S_{maks}-S_{pre}}$, ($S_{pre}$ = pretest score, $S_{post}$ = posttest score, $S_{maks}$ = the ideal maximum score). Data analysis techniques were carried out with the help of Statistical Package for Social Science (SPSS) software. The N-Gain score criteria if 0,70 < N-Gain < 1,00 is high category, 0,30 ≤ N-Gain ≤ 0,70 is average category, and N-Gain 0,00 < N-Gain < 0,30 is low category [27].

## 3. Results and Discussion

In this study focuses on the material logic and sets. The treatment given is by applying a learning model based on teaching material that has been developed in previous studies with 54 students. The steps taken are giving pretest to see students 'higher order thinking skills before treatment, giving treatment, and giving posttest to see students' higher order thinking skills after being given treatment. The description of the research data is presented in table 1 and the full results of the pretest and posttest about the high order thinking skills of students are presented in table 2.

**Table 1. One-Sample Kolmogorov-Smirnov Test**

| | | Pretest | Posttest |
|---|---|---|---|
| N | | 54 | 54 |
| Normal Parameters,b | Mean | 57.6481 | 70.4074 |
| | Std. Deviation | 15.73622 | 16.33669 |
| Asymp. Sig. (2-tailed) | | 0.200 | 0.200 |
| Conclusion: Test distribution is Normal. | | | |

**Table 2. Descriptive Statistics**

| | N | Range | Minimum | Maximum | Mean | | Std. Dev. | Variance |
|---|---|---|---|---|---|---|---|---|
| | Statistic | Statistic | Statistic | Statistic | Statistic | Std. Error | Statistic | Statistic |
| Pretest | 54 | 56.00 | 30.00 | 86.00 | 57.65 | 2.14 | 15.74 | 247.63 |
| Posttest | 54 | 59.00 | 40.00 | 99.00 | 70.41 | 2.22 | 16.34 | 266.88 |
| N-Gain | 54 | 1.25 | -0.31 | 0.94 | 0.32 | 0.04 | 0.31 | 0.09 |

The normality test in table 2 shows that the data is normally distributed, because the value of sig. (2-tailed) > 0,05. The results of the analysis of learning achievement data for 54 students before using brain-based learning showed a range of 56 results; minimum score of 30, maximum score of 86; mean 57.65; standard deviation of 15.74; and variance 247.63. While the results of data analysis of learning achievement after using brain-based learning show the range 59 results; minimum score of 40, maximum score of 99; mean 70.41; standard deviation of 16.34; and variance 266.88. While the results of the N-Gain analysis show that the average N-Gain statistics are 1.25; standard deviation of 0.31; and variance 0.09. The results of the analysis of one sample t-test are presented in table 3.

**Table 3. One-Sample t-Test**

| | Test Value = 65 | | | | | |
|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | |
| | t | df | Sig. (2-tailed) | Mean Difference | Lower | Upper |
| Pretest | -3.43 | 53 | 0.001 | -7.35 | -11.65 | -3.06 |
| Posttest | 2.43 | 53 | 0.018 | 5.41 | 0.95 | 9.87 |

Based on table 3, it was found that pretest t value was -3.43 and Sig. value (2-tailed) was 0,001 < 0,05, then in accordance with the basis of decision making it can be concluded that $H_0$ is rejected and $H_1$ is accepted, thus it can be interpreted that the average pretest score of students is not equal to 65. Then the posttest t velue was 2,43 and Sig. value (2-tailed) was 0,018 < 0,05, thus it can be interpreted that the average pretest score of students is not equal to 65. Average pretest 57.65 < 65. The results of the pretest indicate that the student's higher order thinking skills is not optimal. Posttest average of 70.41 > 65, this shows that brain-based learning can improve students' higher order thinking skills with an N-Gain score of 0.32 included in the average category. Efforts to improve the quality of learning are associated with increasing student learning achievement [28, 29]. The result can be seen in the following figure:

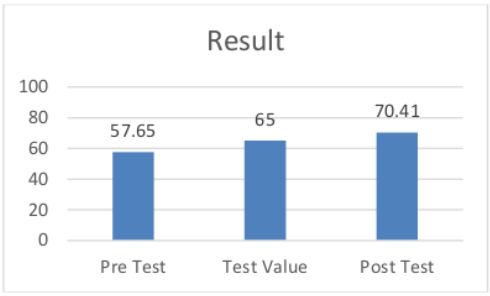


**Figure 1.** Improvement Results

One of the factors influencing the improvement of students' higher order thinking skills is the preparation of teaching materials that are adjusted to the learning objectives [30]. The purpose of learning is to hone higher-order thinking skills, so that the teaching material created is adjusted to the indicators of students' higher-order thinking skills. The teacher's contribution in the process of preparing teaching materials is an important element in the implementation process [31, 32]. In this study the teaching materials used in the learning process are logic and set teaching materials that are proven to be able to improve students' higher-order thinking skills. This can be seen from the post-test mean value which is higher than the pre-test mean value.

An increase in the average value from pre-test to post-test occurs due to increased thinking ability of students. Someone who has good thinking skills can affect his ability to learn, speed of learning and learning effectiveness [13]. Efforts to train students to think critically and creatively show a positive impact on the development of their education [11]. Critical and creative thinking is part of a high-level thinking process. In the high-level thinking process it takes high-level creative thoughts and actions to generate ideas in solving problems [33]. Brain-based learning that is supported by appropriate teaching materials can facilitate students in generating ideas of problem solving.

The knowledge about brain function and its effects on learning have the potential to revolutionize teaching and learning [34]. The new framework for brain-based learning emphasizes reinforcement the neural network in increasing structural responses using a person's feedback control in solving problems [35]. The feedback control supports the achievement of students' higher order thinking abilities. [36, 37] states there is a positive relationship between brain-based learning models and student learning abilities. The brain based learning model has more potential influence on students' learning motivation compared to conventional models [38]. Result of the study [39] which states that the application of brain based learning models can improve activity, thinking ability, and learning outcomes.

## 4. Conclusion

The results showed the pre-test mean value was 57.65, the post-test mean value was 70.41, and the N-Gain mean value was 0.32. This shows that brain-based learning can increase higher order students' thinking skills in logic and set courses.

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## References

[1] Valent W S, Danisa S and Suciati 2015 Pengembangan Modul Berbasis Brain Based Learning Disertai VEE Diagram untuk Meningkatkan Hasil Belajar ranah Kognitif pp 141–151.
[2] Jailani J, Sugiman S and Apino E 2017 Implementing the Problem-Based Learning in Order to Improve the Students HOTS and Characters *J. Ris. Pendidik. Mat.* **4** pp 247–59.
[3] Cahyani H and Setyawati R W 2016 Pentingnya Peningkatan Kemampuan Pemecahan Masalah melalui PBL untuk Mempersiapkan Generasi Unggul Menghadapi MEA pp 151–60.

[4] Adiansha A A and Sumantri M S 2018 Pengaruh model brain based learning terhadap kemampuan komunikasi matematis siswa ditinjau dari kreativitas **8** pp 127–39.
[5] Ikhsan M, Munzir S and Fitria L 2017 Kemampuan Berpikir Kritis dan Metakognisi Siswa dalam Menyelesaikan masalah Matematika Melalui Pendekatan Problem Solving *Aksioma* **6** pp 234-45.
[6] Crismono P C 2017 Pengaruh Outdoor Learning Terhadap Kemampuan Berpikir Kritis Matematis Siswa The Influence Of Outdoor Learning On The Mathematical Critical Thinking Skills Of Students *J. Pendidik. Mat. dan Sains* **1866** pp 106–13.
[7] Wahid A H 2018 Integrasi Higher Order Thinking Skill (HOTS) dengan Model Creative Problem Solving *MODELING* **5** pp 82–98.
[8] Annuuru T A, Johan R C and Ali M 2017 Peningkatan Kemampuan Berpikir Tingkat Tinggi dalam Pelajaran Ilmu Pengetahuan Alam Peserta Didik Sekolah Dasar Melalui Model Pembelajaran Trefinger *EDUTCEHNOLOGIA* **3** pp 136–44.
[9] Hidayati A U 2017 Melatih Keterampilan Berpikir Tingkat Tinggi dalam Pembelajaran Matematika pada Sisiwa Sekolah Dasar *J. Pendidik dan Pembelajaran Dasar* **4** pp 143–56.
[10] Nurmala R and Mucti A 2019 Efektivitas Penggunaan LKM Berbasis HOTS (Higher Order Thinking Skills) terhadap Hasil belajar Mahasiswa Pendidikan Matematika *J. Honai Math* **2** pp 117-28.
[11] Thnull N 2017 Influence of Explicit Higher-Order Thinking Skills Instruction on S tudents ' Learning of Linguistics *Think. Ski. Creat.* **26** pp 113–27.
[12] Richland L E and Simms N 2015 Analogy, Higher Order Thinking, and Education *Cogn. Sci.* **6** pp 177–92.
[13] Yee M H, Yunos J, Othman W, Hassan R, Tee T K and Mohaffyza M 2015 Disparity of Learning Styles and Higher Order Thinking Skills among Technical Students *Procedia - Soc. Behav. Sci.* **204** pp 143–52.
[14] Tajudin M 2016 The Link between Higher Order Thinking Skills , Representation and Concepts in Enhancing TIMSS Tasks *Int. J. Intruction* **9.**
[15] Khasyyatillah I L and Irianti M 2018 Development of Worksheet Based on High Order Thinking Skills to Improve High Order Thinking Skills of The Students **2** pp 37–45.
16] Riadi A and Retnawati H 2014 Pengembangan Perangkat Pembelajaran untuk Meningkatkan HOTS pada Kompetensi Bangun Ruang Sisi Datar Developing Learning Kit to Improve HOTS for Flat Side of Space Competence *PYTHAGORAS* **9** pp 126–35.
[17] Sesmiarni Z 2016 Model brain based teaching sebagai transformasi paradigma pembelajaran di perguruan tinggi **1** pp 93–104.
[18] Kersey A J, Wakim K, Li R and Cantlon J F 2019 Developmental Cognitive Neuroscience Developing , mature , and unique functions of the child ' s brain in reading and mathematics *Dev. Cogn. Neurosci.* **39** p 100684.
[19] Sugiyono S 2017 Metode Penelitian Kuantitatif (Bandung: Alfabeta).
[20] Krisdiana I, Masfingatin T, Murtafiah W and Widodo S A 2019 Research-based learning to increase creative thinking skill in mathematical Statistic Research-based learning to increase creative thinking skill in mathematical Statistic *J. Phys. Conf. Ser.*
[21] Rusnilawati R 2016 Pengembangan Perangkat Pembelajaran Matematika Bercirikan Active Knowledge Sharing dengan Pendekatan Saintifik Kelas VIII *J. Ris. Pendidik. Mat.* **3** pp 245-58.
[22] Sulistyowati Y Pengembangan Perangkat Pembelajaran Bangun Ruang di SMP dengan Pendekatan Creative Problem Solving Developing of Solid Instructional Package with Creative Problem Solving Approach Abstract *PYTHAGORAS* **9** pp 219-32.
[23] Hernawati F 2016 Pengembangan Perangkat Pembelajaran Matematika dengan Pendekatan PMRI Berorientasi pada Kemampuan Representasi Matematis *J. Ris. Pendidik Dasar* **3** pp 34-44.

[24] Arikunto S 2015 Dasar-Dasar Evaluasi Pendidikan Edisi 2," 2nd ed., R. Damayanti, Ed (Jakarta: Bumi Aksara).
[25] Jailani, Sugiman, Retnawati H and Bukhori 2018 Desain Pembelajaran Matematika untuk Melatihkan Higher Order Thinking Skill (Yogyakarta: UNY PRESS).
[26] Kusuma M D, Rosidin U, Abdurrahman A and Suyatna A The Development of Higher Order Thinking Skill (Hots) Instrument Assessment In Physics Study *IOSR J. Res. Method Educ.* **7** pp 26-32.
[27] Situmorang R M, Mahibbuddin and Khairil Penerapan Model Pembelajaran Problem Based Learning untuk Meningkatkan Hasil Belajar Siswa pada Materi Sistem Ekskresi Manusia *J. EduBio Trop.* **3** pp 87–90.
[28] Mikheeva M, Schneider S, Beege M and Rey G D 2019 Boundary Conditions of The Politeness Effect in Online Mathematical Learning *Comput. Human Behav.* **92** pp 419-27.
[29] Brezovszky B, McMullen J, Veermans K, Hannula-Sormunen M M, Rodríguez-Aflecht G, Pongsakdi N, Laakkonen E and Lehtinen E 2019 Effect of a Mathematics Game-Based Learning Environment on Primary School Students' Adaptive Number Knowledge *Comput. Educ.* **128** pp 63-74.
[30] El Soufi N and See B H 2019 Does explicit teaching of critical thinking improve critical thinking skills of English language learners in higher education? A critical review of causal evidence *Stud. Educ. Eval.* **60** pp 140-62.
[31] Murphy C, Bianchi L, McCullagh J and Kerr K Scaling up higher order thinking skills and personal capabilities in primary science: Theory-into-policy-into-practice *Think. Ski. Creat.* **10** pp 173-88.
[32] Sasson I, Yehuda I and Malkinson N 2018 Fostering the skills of critical thinking and question-posing in a project-based learning environment *Think. Ski. Creat.* **29** pp 203-12.
[33] Heong Y M, Yunos J M, Othman W, Hassan R, Kiong T. T and Mohamad M M The Needs Analysis of Learning Higher Order Thinking Skills for Generating Ideas *Procedia - Soc. Behav. Sci.* **59** pp 197-203.
[34] Kapadia R H 2014Level of Awareness About Knowledge, Belief and Practice of Brain Based Learning of School Teachers in Greater Mumbai Region *Procedia - Soc. Behav. Sci.* **123** pp 97–105.
[35] Rahmani H R, Chase G, Wiering M and Könke C 2019 A framework for brain learning-based control of smart structures *Adv. Eng. Informatics* **42**.
[36] Chen H, Song Y and Li X 2019 Neurocomputing A Deep Learning Framework for Identifying Children with ADHD Using an EEG-Based Brain Network *Neurocomputing* **356** pp 83-96.
[37] Yagcioglu O 2014 The Advantages of Brain Based Learning in ELT Classes *Procedia - Soc. Behav. Sci.* **152** pp. 258-62.
[38] Saleh S 2012 The Effectiveness of The Brain Based Teaching Approach in Enhanching Scientific Understanding of Newtonian Physics Among Form Four Students *Int. J. Environ. Sci. Educ.* **7**.
[39] Hamid H, Nurhayati B and Ali A 2014 Peningkatan Aktivitas, Hasil Belajar Afektif dan Kognitif pada Mata Pelajaran Biologi melalui Penerapan Model Brain Based Learning Peserta Didik Kelas VII-A SMP Negeri 4 Sungguminasa Kabupaten Gowa *Jurnal Sainsmat* **3** pp 12-37.

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