Development cognitive neuroscience based learning to use lesson study for learning community to increase mathematical literacy

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Abstract. According to the results of observation with teachers it is known that students still considered topic of fractions were difficult. Students often made mistakes in changing and calculating the fraction of operation. One of the causes in their mathematics literacy was low. Mathematics learning commonly stimulated the work of the right brain and left brain only and ignoring anxiety of students when facing fraction of questions. However, the mathematics learning based on cognitive neuroscience is very needed. This research aims to produce learning model prototype in term of improving students' mathematical literacy with the accompanying impact on the growth of communicative and collaborative skills. The developed model used is 4D (define, design, develop, and disseminate). Methods of data collection used observation, questionnaires, documentation techniques, and tests. The research was conducted in 3 cycles with lesson study for learning communities, each cycle went through 2 stages of a plan-do-see. The research subjects were 40 students in fifth grade of elementary school in the odd semester of 2020. The data were analyzed descriptive qualitatively through data reduction, data presentation, and conclusions. Based on data validation with learning technology experts, learning evaluation experts, and neurosains experts got a good value category, so that the learning model prototype was suitable to use in learning. The results of the pre-test post-test value of the learning implementation were analyzed using the paired sample T-Test obtained by $t_{Stat} = -2.87 < t_{Critical two-tail} = 2.02$ which was learning model prototype can improve students' mathematical literacy. The Mathematical anxiety shown a decreasing, the communicative skill of students grew, the collaborative skill had not shown a significant increase. So it can be concluded that the learning model prototype is effective.

1. Introduction
The goals of 21st century education place more emphasis on the aspects of character development, competence and literacy. The Partnership for 21\textsuperscript{st} Century Skills \cite{1} has developed the 21\textsuperscript{st} Century Learning Framework which describes future competencies. A number of strategic skills which include life skills, study skills and innovation, as well as mastery of information technology are described in detail as follows: (1) life and career skills consisting of flexibility and adaptability, initiative & self-direction, social and cross-cultural skills, productivity & accountability, and leadership &responsibility, (2) learning skills and innovation consist of critical thinking, communication, collaboration, and creativity, (3) mastery of information, media, and technology \cite{2}. Mathematics learning as one of the national compulsory subjects has an important role in achieving this goal. Based on the results of the 2018 Program of International Student Assessment (PISA) survey \cite{3}, Indonesian
students' mathematical literacy has decreased. Previously, many efforts had been made such as the development of PISA model questions, the application of realistic mathematics learning models and so on, commonly Indonesian teachers teach mathematics learning stimulating the work of the right brain and left brain only and ignoring anxiety of students when facing fraction questions. So that efforts are needed to develop an appropriate learning model from an early age, which considers the psychological aspects of students. It needed to build strong mathematical literacy and the development of communicative and collaborative character for elementary school students, otherwise to meet the demands of the 21st Century Learning Framework.

The students are still having difficulties in understanding the arithmetic procedures of the fraction especially the addition and subtraction [4]. The student does not yet know that addition and subtraction operations must equalize the denominator first. Therefore, it would be better to do further research on the causes of misconceptions about the addition and subtraction of fractions of subsequent improvement of understanding the student’s concept that accompanying impact on the growth of mathematical literacy in various classes, especially in primary schools. In another research, Triyono [5] say that the mastery-concept on addition and subtraction of fraction at fifth-grade students is still low. Finally, the impact can make most primary student think that learning addition and subtraction of fraction in mathematics is difficult. Students' mastery-concept on addition and subtraction dominated by category 'misconception'.

Mujulifah et al. [6] have conducted research on mathematics literacy at the junior high school level regarding communication aspects, students tend not to be fluent in expressing the results of their thoughts and in using mathematical language to express mathematical ideas appropriately. In addition to the communication aspect, the basic character that needs to be developed for 21st century students is the ability to collaborate [7]. This ability needs to be developed at an early stage of students, because student’s character is easily shaped if taught early. Neuroscience is a new educational system that studies the nervous system. Educators generally rarely pay attention to this problem. Neglect of this system causes the learning atmosphere to die [8]. Meanwhile, Lesson Study for Learning Community (LSLC) is a type of lesson study that can build collaborative abilities and train collaboration between work groups to create an atmosphere that makes students learn from other students, not allowing students to feel neglected and inadequate [9].

Research on neuroscience has been widely carried out in the world of education. Tantowie [10] developed a neuroscience-based learning model to improve creative character, hard work and curiosity with the results of research showing that the model is effective in increasing the achievement of students' academic competence, and is effective for increasing the character of hard work. Burhaein [11] in his research concluded that traditional game activities based on neuroscience learning can be used to optimize education character for children with behavioral and emotional disorders. Choirul Annisa [12] concluded that the management of mathematics learning based on neuroscience studies is (1) emotional control, by creating a happy emotional atmosphere, (2) cognitive control, by choosing methods that support brain performance, and (3) motor control, by involving physical motion in the learning process, (4) metacognitive skills encourage students to do all fearless learning actions are blamed by the surrounding adults. So the researcher concluded that a learning model is needed for elementary school students who consider the psychological aspects of students based on cognitive neuroscience theory with LSLC which can have an impact on increasing students' mathematical literacy.

2. Method
This research used research and development (R&D) methods. The research steps referred to Thiagarajan's (4D) opinion, which includes four stages: Define, Design, Develop, and Disseminate [13]. The subjects of this research were students of fifth grade of elementary school student at odd semester. The data were collected through three stages, (1) the stage of the preparation of learning tools and learning designs based on cognitive neuroscience, (2) the validation and revision stages, and (3) the implementation stage of classroom learning using the one group pretest-posttest design. This...
research was conducted at the Integral Islamic Elementary School Nurul Islam Klakah Lumajang odd semester at 2020, with 40 grade students as research subjects. Methods of data collection using observation, questionnaires, documentation techniques, and tests. This observation was carried out by direct observation of the teaching and learning actions of students, especially in terms of doing the Plan, Do and See stages.

Activities in the Plan stage were re-discussion of the lesson plan and student’s workbook with expert reviews. In the Do stage, learning activities were carried out according to the plan at the neuroscience cognitive learning design stage. While in the See stage, the researcher reflected on the learning process that had been carried out in relation to student activities and teacher activities. Test data collection was used to determine student learning achievement and mathematical literacy abilities. Meanwhile, documentation was used to record all learning processes. The instruments used were teacher and student observation guidelines, as well as mathematical literacy test questions. The validity of the data was obtained by triangulation of sources and methods. Data analysis was carried out in a descriptive qualitative manner with a flow method consisting of data reduction, data presentation, drawing conclusions and verification.

In the development process, [14] states that the team of experts involved in the validation process consists of: learning technology experts, subject matter experts, learning outcome evaluation experts. Thus, the subjects of this study were learning technology experts, learning evaluation experts, neuroscience experts, students, observation, questionnaires, documentation techniques, and tests. The research was conducted in 3 cycles with lesson study for learning communities; each cycle went through 2 stages of a plan-do-see. Data analysis technique used was learning model prototype...
validation analysis and feasibility test. The learning model was analyzed by using a rating scale with four choices of answers: "very poor," "lacking," "good," and "very good." Table 1 is the criteria for the validity of teaching materials to measure the feasibility of the learning model adapted from [15].

| Percentage (%) | Validity level |
|---------------|----------------|
| 85 - 100      | Very valid or usable but needs to be revised. |
| 70 - 85       | Valid or usable but needs to be revised. |
| 50 - 70       | Less valid is recommended not to be used. |
| 1 - 50        | Invalid or may not be used. |

3. Result

The research process began with an initial analysis of cognitive neuroscience theory, lesson study for learning communities, mathematics literacy, and the fifth grade mathematics learning curriculum at Indonesian elementary school. Next was the design and validation stages, limited class and small class trials. The following is a description of each stage.

3.1. Initial Analysis

The research implementation begins with an initial analysis of cognitive neuroscience theory, lesson study for learning communities, mathematics literacy and the odd semester of fifth grade elementary school mathematics curriculum.

Cognitive neuroscience is a cognitive study of learning memory, perception, and thinking. Cognitive neuroscience is one of the fastest growing fields of science [16]. The relationship between cognitive neuroscience and mathematics education is the existence of cognitive characteristics (aculculia, dyscalculia, math anxiety) and interventions (Accelerated Math, Corrective Mathematics, FAST Math, Number Worlds, The Number Race) in improving mathematical cognition [17].

Generally, the lesson study learning steps are plan, do, see. Teaching practice and reflective practice are explicated to underlie the proposed framework of substantive aspects of lesson study [18]. The main elements in learning Lesson Study for Learning Community (LSLC) in [19] are (a) applicative learning. Applicative learning means that learning applies or implements thinking activities to solve problems, activities by applying what is learned; (b) learning from each other in small groups (collaborative learning), in the Lesson Study for Learning Community, students form groups of four or pair up with gender cross seating plans, plenary interaction; (c) expression and interaction (caring community), student interaction with students in the learning process, the teacher's role is to listen, connect and relearn; (d) jumping Task. Jumping tasks are questions or tasks that encourage students to try or solve problems of a higher level so that their cognitive abilities increase. The level of the jumping task question is in the form of application questions or more developed, which not all students have to be able to solve.

In [20] mathematical literacy is defined as follows: “Mathematical literacy is an individual’s capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens”.

The subject matter of fifth grade elementary school mathematics in Indonesia includes counting operations for fractions, velocity and discharge, plans and scales, cubes and cuboid, and data processing. Based on these theories, the researcher designed cognitive neuroscience-based learning to improve elementary school students’ mathematical literacy with fraction material learning designs.
3.2. Design

The design stage went through several meetings, discussion group forums, and inviting resource persons to finally produce a draft of the learning model, literacy criteria, expert validation sheets and questionnaires. Jodi Tommerdahl [21] who stated that it is unlikely that the findings of the neuroscience laboratory can be directly applied to learning in the classroom. Therefore, he built a solid bridge to connect the mind, brain, and education; from the neuroscience laboratory to practical learning in classrooms. Jodi Tommerdahl proposes five steps to implement research findings in the neuroscience laboratory into classroom learning practices, namely neuroscience, cognitive neuroscience, psychological mechanisms, educational theory, and classroom learning. Figure 2 is a bridge between education and neuroscience.

Based on the connecting bridge figure 2, a learning design was compiled that considers psychological mechanisms and educational theory. Figure 3 is the result of the design of the learning model developed in this study.

![Figure 2. Bridge connecting education and neuroscience](image)

The learning model stage follows the Lesson Study flow, namely the plan-do-see stage. However, the "DO" stage still allows for modification of learning according to cognitive neuroscience theory. The identification stage was carried out before learning to determine the mathematical characteristics of students according to cognitive neuroscience theory, namely aculculia, dyscalculia, and math anxiety. The Do stage was based on the cognitive neuroscience theory as are follows.

![Figure 3. Neuroscience Cognitive-LSLC Prototype](image)

(1) Focusing: In the early stages of learning, students have different initial conditions. Some are ready to learn, some are still lazy, etc. Learning is done by preparing the brain in a state ready to learn [22], namely the Alpha wave 8-12Hz aware / relax / calm down through various ways. At this stage of focusing, you can also give positive suggestions to students. According to Jensen [23], the first thing that needs to be understood in giving suggestions to students is to use positive sentences. The language used must be short and clear, easy for the child to understand, contain certainty, avoid using words as possible, supposing, etc., according to the child's intellectual level, according to the child's
developmental age, use positive words and repeat it many times, otherwise avoid using negative words, don't use the word "should" which seems to force the child, avoid using the words "no", "not", and "don't". (2) Manipulation: improving performance in solving math problems requires equalizing the functions of the left brain and right brain, and maximizing the work of the prefrontal cortex. In addition, a strong positive stimuli for the amygdala are needed so that mathematics can stick into a person's memory without causing dislike, fear or anxiety. In other words, mathematics needs to be manipulated into something fun [24]. (3) Intervention: Five mathematics intervention programs that have shown support from empirical research, peer-reviewed according to [25] are Accelerated Math, Corrective Mathematics, FAST Math, Number Worlds, The Number Race. Then, (4) Evaluation: in every lesson it is necessary to carry out an independent evaluation by each student so that they understand where the error lies and which solution is correct. The evaluation system is carried out with the corrective mathematical model, which is to judge by points through an error scale, and a student progress diagram. This step was used to increase Mathematical Literacy, Communication and Collaboration Skills, and the anxiety with Criteria as show in table 2.

| Skill & completeness | Indicator                                                                 |
|---------------------|---------------------------------------------------------------------------|
| Mathematical literacy | Students can correctly formulate, use, and interpret mathematical fractions in various contexts and use mathematical thinking patterns in making decisions on everyday problems |
| Anxiety             | Students dislike mathematics lesson                                         |
| Collaborative       | Students collaborate and exchange information between groups               |
| Communicative       | Students fluently express opinions and ask a lot of questions              |

The results of validation by education experts, mathematical literacy experts, and neuroscience experts regarded the learning plans and Corrective Mathematic Workbook so that have been developed, which can be used with minor revisions. After all the research instruments were revised according to the input and suggestions of the experts, the next stage was the prototype 1 trial in small classes, self-evaluation and revision.

3.3. Implementation

There were two classes, namely the VA class and the VB class. The research was carried out in three cycles with each cycle consisting of two stages with material according to the grade V SD curriculum in odd semesters, namely the fraction operation. Based on the results of the 2011 TIMSS score analysis in research [26], the level of truth of Indonesian students answering TIMSS questions in the domain of number content with the topic of fractions and decimals is 8% for knowledge level questions and 9% for application level questions. This certainly shows that Indonesian students still experienced difficulties in fractions and decimals. This is consistent with the initial findings at the identification stage on this research that students often make mistakes when adding fractions, student write the answer of $\frac{1}{3} + \frac{2}{3} = \frac{3}{3}$. This has an equal result with the research of Hea-Jin Lee [27] that common misconceptions were associated with a lack of understanding of basic definition of fractions, least common denominators/least common multiples, and order of operations.

The identification stage was carried out at the beginning of learning and data obtained from more than 50% of students experiencing math anxiety. The next lesson is to focus on students by tapping the Character Education Strengthening and after the evaluation stage, focusing on learning by singing fraction songs. Here are the lyrics of the song. "come on our friends lets learning together | Divide a number into fractions, over the numerator | below the denominator, do not be back and forth | times the same number | so that it becomes a fraction of same value | divide by the same number | so that it becomes a fraction of same value | equal together first, equal the denominator and then added: Fractions --- easy to solve."
The next stage was the mathematical manipulation. At this stage, the researcher developed teaching aids that can display the real form of a fraction. It consisted of a modified whiteboard and several small colorful squares. This board can be used as a medium for visualizing the form of fractions, visualizing addition, subtraction, and multiplication of fractions as shown in Figure 4.

In the group discussion process, students were given the freedom to choose any location. Student comfort was important in the discussion process. In this discussion process, groups tended to focus on discussions with their group members and did not ask other groups. Students tended to directly ask the teacher if there are difficulties. At the mathematical discussion and communication stage students tended to actively ask questions and dared to convey opinions. One of the groups that made a mathematical error was asked to present the answer.

![Figure 4. Fraction manipulation](image)

The data obtained were errors made by students in the fraction addition operation, namely \( \frac{1}{2} + \frac{1}{3} = \frac{1}{5} \). So that the next stage was to discuss the opinions of other groups and mathematical manipulation and explanation of reinforcement from the teacher. The intervention process was carried out by means of corrective mathematics, namely by developing student workbooks with a system for assessing the number of student errors, so that students will remember where the mistakes were and stored in long-term brain memory. The evaluation process was carried out by discussing and correcting students' answers together and testing several mathematical literacy questions.

4. Discussion
The discussion stage discusses research findings in terms of cognitive neuroscience, mathematical literacy, and the results of statistical analysis of the development of learning models.

4.1. Cognitive Neuroscience and Mathematical Literacy Analysis
The final stage was the self-evaluation and the mathematical literacy test. In general, the data obtained showed that student anxiety had decreased significantly and students' mathematical literacy skills had increased, as well as increased mathematical communication skills but students' collaborative abilities did not experience significant growth. It can be seen directly in Figure 5 that mathematics anxiety was inversely related to students' mathematical communication skills and literacy.

Increased mathematical literacy and communicative skills from students decreased students' mathematical anxiety because the learning model implemented in Cognitive Neuroscience learning is fun learning and the results are always reviewed at the see stage in the Lesson Study cycle. This is in line with the findings of Asep Supena [28] that the concept of learning in a neuroscience perspective is learning that empowers the brain's abilities by creating a learning environment that is challenging, fun, meaningful, and encourages students to be active. Thus, educational neuroscience is an important future educational model for primary school teachers to know.
Communicative skills are one of the 21st century abilities that students must have which are summarized in 4C (Communicative, Collaborative, Critical, and Creative). In this study, literacy skills develop in line with students’ communication skills. This is in accordance with the literacy indicators in the research of Zakkia et al. [29] that the indicators of mathematical literacy were communication, mathematizing, representation, reasoning and argument, devising strategies for solving problems, using symbolic, formal and technical language and operation, and using mathematics tools.

Based on the results of the evaluation of mathematical literacy, important findings were obtained regarding students’ knowledge about adding fractions. In cycle 1 mathematics intervention was carried out by students working on corrective mathematics sheets and many errors were found, students studied too seriously and did not move. In cycle 2 mathematical intervention was carried out by developing student worksheets into stories about Covid-19 and linked with fraction material. In cycle 3, development was carried out again by giving group games. Students tend to be active and dare to communicate answers. In this case, the students' collaborative abilities did not really appear. Based on the results of observations (figure 6), students who have anxiety have a negative effect on students’ mathematical abilities and mathematical literacy. This was in line with Ika's research[30] that any negative relationship between math anxiety with mathematical connection were capabilities.

![Figure 5. Skill Progress](image)

![Figure 6. Student’s anxiety and its mathematical literacy](image)

![Figure 7. Basic concepts of fraction](image)
After learning through cognitive neuroscience was carried out, students can understand the basic concept of fractions through mathematical manipulation with square fractions props (figure 4). However, not all students successfully interpreted the problem correctly. So, the teacher must emphasize that in the fraction, the parts must exactly equal. This can be seen in the students' answers as in Figure 7.

At the time of mathematical manipulation, the teacher's creativity was needed in modifying the mathematics to become real for elementary students. This proved effective when applied in cycle 3, namely by modifying the basic concept of fractions with a story about the corona virus, of course with language that was easy to understand and in accordance with the child's level of thinking. The majority of students can answer correctly (Figure 8).

![Figure 8. Mathematics manipulation](image)

The recapitulation results of the learning implementation are presented in table 3. It can be seen that the activities of focusing and manipulating mathematics can have many versions, so that through this learning model, teachers are required to always innovate and be creative in each lesson.

| Learning Steps | Cycle 1            | Cycle 2            | Cycle 3            |
|----------------|--------------------|--------------------|--------------------|
| Focusing       | Positive communication | Mini yell-yell | Singing Math fraction |
| Manipulation   | Fraction puzzle     | Mini game          | Corona Virus Story |
| Intervention   | Corrective Math     | Corrective math    | Corrective math    |

4.2. Statistical Analysis

Evaluation of the effectiveness learning model tools developed was carried out with Classroom Action Research. It was appropriate according to[14] that effectiveness testing can be done by experiment or Classroom Action Research (CAR). How to test the effectiveness of learning through CAR can be done by measuring competencies before and after learning, in this case the competence being measured was the competence of mathematical literacy in fraction material. If the competence after learning is better than before, the learning model developed is also declared effective. At the initial stage, a pre-test was carried out on students in the class. After going through the learning implementation activities with the developed neuroscience model, a post test was carried out. The pre-test posttest value of mathematical literacy was analyzed using the Kolmogorov Smirnov normality test using Microsoft Excel with the results of statistical data N sample 40, mean 0.925, standard deviation 0.764 and Dₙ (Kolmogorov smirnov count) = 0.212 <KS table (Kolmogorov smirnov table) = 0.215 with the conclusion of normal data in distribution. After confirming the normal data, the t-test: Paired Two Sample for Means was carried out using Microsoft Excel data analysis to obtain data on differences in student competencies before and after treatment, obtained person correlation data of 0.875 which showed a very strong correlation. Hypothesized Mean Difference 0 means that in this data analysis the researcher assumes there is no difference in the average of the research subjects. The
t test results show that the $t_{stat} = -2.876 < t_{critical}$ two tail = 2.022, which means that the post-test results between before treatment and after treatment have a significant difference.

This research is a developmental research that produces a product of prototype. The product produced from this research is a prototype learning model based on cognitive neuroscience. After going through the research stages, through the results of validation with educational technology experts, neuroscience experts, learning outcomes evaluation experts, individual tests, and small group tests, the percentage of results ranged from 80% to 85%, good value categories and can be said to be suitable for using in activities learning [31].

The pre-test and post test results obtained were calculated using the t-test and obtained $t = -2.876$. Then the $t$ value is consulted with the $t$ distribution table using a significant level of 5% and $D_f = n-k = 40-1 = 39$, the $t$ value is two tail critical = 2.022. From the results of the consultation between $t$ count / $t$ stat and $t$ table / $t$ critical, it was obtained $t$ arithmetic < $t$ table, the results of pre-test and post-test between before and after were significant differences. It can be concluded that the learning model is effectively used in learning activities.

5. Conclusion

This section contains conclusions according to the research objectives. Based on the analysis of data, it can be concluded that the formulation of the learning model that has been successfully developed is Identification - Plan - Do (Focusing, Manipulation, Intervention, Evaluation) - See. Based on data validation with learning technology experts, learning evaluation experts, and neurosains experts by getting a good category, the learning model prototype can be said to be suitable to use in learning. The results of the pretest-posttest value of the learning implementation were analyzed using the paired sample t-test obtained by $t_{Stat} = -2.87 < t_{Critical}$ two-tail = 2.02 which is learning model prototype in can improve students' mathematical literacy. The Mathematical anxiety shown a decreasing, the communicative skill of students grew, but the collaborative skill had not shown a significant increase. So it can be concluded that the learning model prototype is effectively used in learning.

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References

[1] P21 2019 Framework for 21st Century Learning Partnersh. 21st century Learn.

[2] Jia Y, Oh Y J, Sibuma B, LaBanca F and Lorentson M 2016 Measuring twenty-first century skills: development and validation of a scale for in-service and pre-service teachers Teach. Dev. 20 229–52

[3] Schleicher A 2019 PISA 2018: insights and interpretations OECD Publ. 64

[4] Deringöl Y 2019 Misconceptions of primary school students about the subject of fractions: views of primary teachers and primary pre-service teachers Int. J. Eval. Res. Educ. 8 29

[5] Trivena V, Ningsih A R and Jupri A 2017 Misconception on Addition and Subtraction of Fraction at Primary School Students in Fifth-Grade J. Phys. Conf. Ser. 895

[6] Mujulifah F, Sugiatno S and Hamdani H 2014 Students’ mathematical literacy in simplifying algebraic expressions (Tanjungpura University)

[7] Saito E, Watanabe M, Gillies R, Someya I, Nagashima T, Sato M and Murase M 2015 School reform for positive behaviour support through collaborative learning: utilising lesson study for a learning community Cambridge J. Educ. 45

[8] Wijaya Hengki 2018 Neuroscience Education and Its Implications in Today's Education Basic Educators. 2 1–19

[9] Ursulasari Y and others 2019 The effectiveness of learning cycle with lesson study for learning community to build students creative thinking skills on algebraic form Journal of Physics: Conference Series vol 1265 p 12007
[10] Tantowie T 2014 *Development of Neuroscience Based Learning Model to Improve Character Education for Children with Behavioral, Emotional, and Social Problems*. Tunalaras the 4th International Conference on Physical Education, Sport and Health (ISMINA) and workshop: Enhancing Sport, Physical Activity, and Health Promotion for a Better Quality of Life. p 124

[11] Burhaein E 2017 *Activities of traditional game based neuroscience learning as character education for children with behavioral, emotional, and social problems*. Faculty of Science Education, Universitas Negeri Yogyakarta

[12] Annisa C 2020 Neuroscience studies: Rationalization of character education in mathematics learning based on metacognitive strategies. *J. Pembang. Pendidik. Fondasi dan Apl.* 7

[13] Ghuftron A 2011 Research and Development (R&D) Approach in the field of education and learning. *Faculty of Science Education*.

[14] Mulyatiningsih E 2016 Learning Model Development retrieved from http://staff.uny.ac.id/sites/default/files/pengabdian/dra-endang-mulyatiningsih-mpd/7cpengembangan-model-pembelajaran.pdf. pada Sept.

[15] Kristanto A, Mustaji, Mariono A, Sulistiowati and Afifah 2019 Development of education game media for xii multimedia class students in vocational school. *J. Phys. Conf. Ser.* 1387

[16] Wathon A 2016 Neuroscience in Education. *J. LENTERA Study. Religion, Science and Technology*. 14, 284–94

[17] Dessy Noor Ariani A S 2019 Cognitive Neuroscience of Mathematics Education in Elementary School. *J. Theorems (The Orig. Res. Math.)* 3, 157–68

[18] Tatang S 2012 Lesson study in Indonesia: an Indonesia University of Education experience. *Int. J. Lesson Learn. Stud.* 1, 196–215

[19] Hobri H 2016 Lesson study for learning community: review of short term on lesson study v results in *Japanese proceedings of semnasdik 2016 Prodi Pendidikan Matematika FKIP Universitas Madura* (Pamekasan)

[20] Hidayati N A, Waluya S B and others 2020 Statistics literacy: what, why and how? *Journal of Physics: Conference Series* vol 1613 p 12080

[21] Tommerdahl J 2010 A model for bridging the gap between neuroscience and education. *Oxford Rev. Educ.* 36, 97–109

[22] Lucy B, Si P, Ht C and others 2012 *5 minutes to master hypnoparenting* (PENEBAR PLUS+)

[23] Jensen E 2008 Enrich the brain: How to maximize the potential of each learner. *Translated by A. Reni Eta Sitepoe. Indonesia. PT Indeks*

[24] Herma A, 2017 Teaching STEM Material - Neuroscience and Math Education in Indonesia *Biotechnology and Neuroscience Surya University*

[25] Kroeger L A, Brown R D and O’Brien B A 2012 Connecting Neuroscience, Cognitive, and Educational Theories and Research to Practice: A Review of Mathematics Intervention Programs. *Early Educ. Dev.* 23, 37–58

[26] Shodiq L J, Tirta I M and others 2011 Analysis of TIMSS Mathematics Problems 2011 With High difficulty Index For Junior high school Students

[27] Lee H-J and Boyadzhiev I 2020 Underprepared College Students’ Understanding of and Misconceptions with Fractions. *Int. Electron. J. Math. Educ.* 15

[28] Hamdan Husein Batubara and Asep Supena 2018 Educational Neuroscience In Basic Education *J. Basic Educator* 140–8

[29] Zakkia A, Isnarto, Asih T S N and Wardono 2019 Students' Mathematical Literacy Ability in Brain Based Learning. *Prism. Pros. Semin. Nas. Mat.* 2, 34–9

[30] Anita I W 2014 The Effect of Mathematics Anxiety on the Mathematical Connection Ability of Junior High School Students. *Infin. J.* 3, 125

[31] Arikunto S 2013 Research Procedure A Practical Action