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Student Errors in Solving Higher Order Thinking Skills Problems: Bridge Context

Muhammad Irfan
Mathematics Education Department, Universitas Sarjanawiyata Tamansiswa,
muhammad.irfan@ustjogja.ac.id

Sri Adi Widodo
Mathematics Education Department, Universitas Sarjanawiyata Tamansiswa,
sri.adi@ustjogja.ac.id

Fitria Sulistyowati
Mathematics Education Department, Universitas Sarjanawiyata Tamansiswa,
fitria.sulistyowati@ustjogja.ac.id

Deri Fathurrahman Arif
Mathematics Education Department, Universitas Sarjanawiyata Tamansiswa,
deryfathur0804@gmail.com

M. Wahid Syaifuddin
Mathematics Education Department, Universitas Widya Dharma,
wahidsyaifuddin@unwidha.ac.id

ABSTRACT

Errors in associating some knowledge result in students' mistakes in choosing strategies so that problems cannot be solved. In fact, the new curriculum in Indonesia requires students to be able to solve problems that require higher-order thinking skills. This study aims to describe how students process problems in solving bridge context problems. This research is qualitative research with case study method. This research was conducted in April 2022 with the research subject being a junior high school student in Yogyakarta, Indonesia. The instrument in this research is the problem of high order thinking (HOT) to measure problem solving ability. The instrument was designed based on the mathematics material that students had learned and compiled through five times Focus Group Discussion (FGD) by 3 mathematics lecturers. Data were collected using documentation and interviews then will be analyzed descriptively. Based on the results and discussion presented in the previous section, the authors collect three types of errors in solving problems made by students. The three types of errors are operational, conceptual, and principal errors.
Keywords: *Student error, Solving Problem, Bridge Context, Higher Order Thinking Skills*

ABSTRAK

Kesalahan dalam mengasosiasikan beberapa pengetahuan mengakibatkan kesalahan siswa dalam memilih strategi sehingga masalah tidak dapat diselesaikan. Padahal, kurikulum baru di Indonesia menuntut siswa untuk mampu memecahkan masalah yang membutuhkan kemampuan berpikir tingkat tinggi. Penelitian ini bertujuan untuk mendeskripsikan bagaimana siswa memproses masalah dalam menyelesaikan masalah konteks jembatan. Penelitian ini merupakan penelitian kualitatif dengan metode studi kasus. Penelitian ini dilaksanakan pada bulan April 2022 dengan subjek penelitian adalah seorang siswa SMP di Yogyakarta, Indonesia. Instrumen dalam penelitian ini adalah soal berpikir tingkat tinggi (HOT) untuk mengukur kemampuan pemecahan masalah. Instrumen dirancang berdasarkan materi matematika yang telah dipelajari mahasiswa dan disusun melalui lima kali Focus Group Discussion (FGD) oleh 3 dosen matematika. Data dikumpulkan dengan menggunakan dokumentasi dan wawancara kemudian akan dianalisis secara deskriptif. Berdasarkan hasil dan pembahasan yang disajikan pada bagian sebelumnya, penulis mengumpulkan tiga jenis kesalahan dalam menyelesaikan masalah yang dilakukan oleh siswa. Ketiga jenis kesalahan tersebut adalah kesalahan operasional, konseptual, dan prinsipal.
Kata Kunci: Kesalahan Siswa, Pemecahan Masalah, Konteks Jembatan, Keterampilan Berpikir Tingkat Tinggi

INTRODUCTION

There are four competencies in the 21st century that students need to possess, namely: communication, collaboration, critical thinking, and creativity (Cho & Lee, 2008; Kim & Md-Ali, 2017; Sugiarti et al., 2018; Wojciehowski & Ernst, 2018). In achieving these competencies, high-level abilities are needed, while high-level abilities can be honed through a high-level problem solving process (Aini et al., 2020; Mingus, 2014; Sulistyowati et al., 2017). Problem solving ability can be interpreted as a person's ability which includes a series of cognitive procedures and thought processes to respond or overcome obstacles or obstacles when an answer or answer method is not yet clear in achieving certain goals (Delice & Sevimli, 2010; Kim & Md-Ali, 2017; Rohaeti, E. E., Nurjaman, A., Sari, I. P., Bernard, M., & Hidayat, 2019; Simamora & Saragih, 2019). Polya conveyed four steps in the problem solving process, namely: (1) understand the problem; (2) see the various items are connected; (3) carrying out the plan; (4) look back at the complete solution (Polya, 1973; Sukoriyanto et al., 2016; Widodo et al., 2018). Students who can carry out the problem-solving process have indirectly honed their high-level abilities as one of the efforts to achieve the four 21st century competencies.

The problem is, not all students can do the problem-solving process well. For example, given the problem that can be seen in Figure 1. To solve the problem in Figure 1, knowledge of the phases of the moon is required. When students do not choose the right position of the moon during the first quarter phase, students cannot solve the problem in Figure 1 using the Pythagorean theorem (because there is no 90-degree angle). At this stage it can be said that students made mistakes in carrying out steps (1) and (2) in problem solving, namely in understanding the problem and relating it to other knowledge which resulted in inaccurate choosing a strategy to solve the problem (step 3) in Figure 1. So, students do not carry out the problem-solving process completely. This shows the weak ability of students to understand and relate some knowledge to get the right strategy in solving problems using the Pythagorean concept and the moon phase.

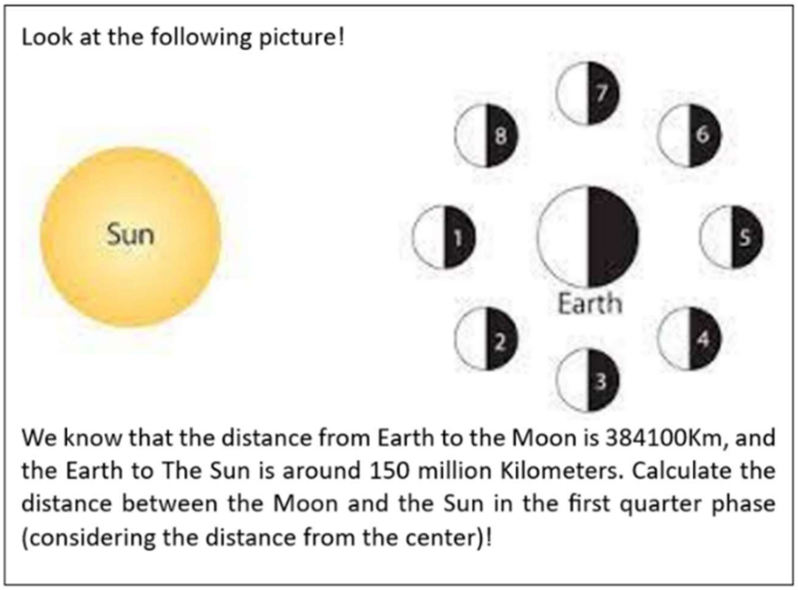


Figure 1. The problem for problem-solving ability

Another problem related to problem solving is that there are still many middle high school students with various characters and personalities in Indonesia who have not been able to apply problem solving steps completely and precisely (Walle et al., 2010; Wen Chun & Su Wei, 2015). Many factors underlie this problem, one of which is the learning carried out by the teacher has not facilitated students to develop students' ability to solve problems (Alibali & Sidney, 2015; Walle et al., 2010; Widodo et al., 2018).

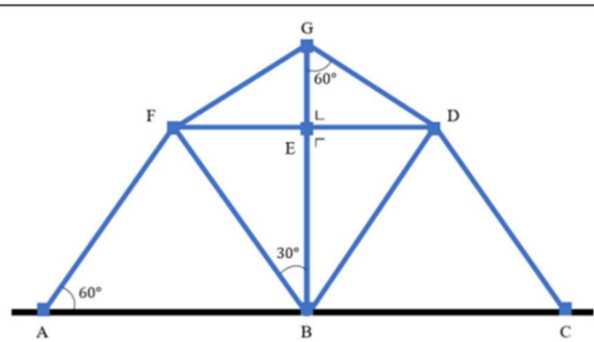
Errors in associating some knowledge result in students' mistakes in choosing strategies so that problems cannot be solved. On the other hand, students have not received learning that is able to strengthen problem solving abilities. In fact, the new curriculum in Indonesia requires students to be able to solve problems that require higher order thinking skills (HOTS) (Aizikovitsh-udi & Cheng, 2015; Hadi et al., 2018; Lubezky et al., 2004). Various HOTS problems are presented in various contexts, for example students' skills in completing jumping tasks (Putri, 2018), higher order thinking skills associated with students' mathematical disposition abilities (Facinoe et al., 1995; Stanovich & West, 2007), students' ability to solve geometric problems (Dogan-Dunlap, 2010). From these various studies, there has been no research that examines student errors in solving HOTS problems in the context of bridges. Thus, this study aims to describe how students make mistakes in solving bridge context problems. This is interesting for the writer because students have often seen steel bridges around them. So, this certainly helps students in visualizing the bridge.

METHOD

This research is qualitative research with case study method which aims to describe how students make mistakes in solving bridge context problems. This research was conducted in April 2022 with the research subject being a student of SMP Yogyakarta, Indonesia. The subject (S) was chosen from 5 students with the highest math scores from all students at the same level. S is the student with the most complete completion steps compared to other students. In addition, S worked on the questions independently, focused and did nothing other than work on the questions. That is, there are no other factors that influence S in solving the given problem. The instrument in this research is the problem of high order thinking (HOT) to measure problem solving ability. The instrument was designed based on the mathematical material that students had learned and compiled through five times Focus Group Discussion (FGD) by 3 mathematics lecturers. Data were collected using documentation and interviews then will be analyzed descriptively. Documentation aims to obtain student answers in solving HOT questions while interviews aim to explore student errors in finding strategies in solving the problems given.

RESULT AND DISCUSSION

The field data obtained in this study are: (1) the results of the HOT problem test of S on problem solving abilities; and (2) script answer S during the interview about what the difficulties were and why to use this strategy in solving the given HOT problem. Before discussing the results of the analysis that has been carried out, it will be explained in advance the form of the HOT problem carried out by S. The HOT problem can be seen in Figure 2.



A contractor will construct a bridge with the design above. The H Beam steel structure of the bridge is illustrated with blue lines, excluding each square lock on each corner of the bridge. AC is the base of the bridge, $AB = 5$ meters, and FG = ¼ of area ΔABF. To construct the bridge, the contractor wants to buy H Beam steel as needed. The price of H Beam steel per meter is 644,000 IDR. Calculate the contractor's expenses to buy the H Beam steel needed! (Use 2 digits rounding).

Figure 2. The HOT problem

The problem given in Figure 2 can be solved using the Pythagorean theorem. However, other knowledge is needed before applying the Pythagorean theorem, namely angles, congruences, congruences, parallelograms, kites, and triangles. Therefore, there are several settlement processes, namely: (1) understanding and determining the connection between the solution and other knowledge (angles, congruences, parallelograms, kites, triangles); (2) designing the most effective and efficient strategy by linking other knowledge for completion; (3) implement the chosen strategy; (4) checking the implementation with what was asked (summing up the contractor's expenses). The settlement process shows the existence of a problem solving ability process (Abidah et al., 2020; Irfan et al., 2019; Simamora & Saragih, 2019; Suryaningrum et al., 2020). Therefore, solving the problems in Figure 2 is a way to identify students' problem-solving abilities.

The strategy used by S in solving The HOT Problem (THP) can be seen in Figure 3. S made several mistakes which were divided into: operational, conceptual, and principal errors. In Figure 3, the error committed by S is coded in terms of Ea and Eb with Ea divided into Ea1 and Ea2. Ea2 is an error that occurs because of an error Ea1 and (Ea2+Eb) is an error that occurs because of an error Ea2 and Eb.

In Ea1, S assumes the length $\overline{BE}$ is 4.5 meters. The basis of this assumption is that the results of measurements using a ruler made by S show a length $\overline{BE}$ 4.5 cm. The impact of this assumption is Ea2 which produces a length $\overline{FE}$ 2.38 meters. In Eb, S made an error when searching for the area of ΔABF by choosing 5 meters as the height of ΔABF so that the calculation results to find the length $\overline{FG}$ are also not correct. The impact of the error Ea2 and Eb is (Ea2+Eb), which is an error in determining the length $\overline{GE}$ by utilizing the results of Ea2 and Eb. Some of the errors that have been described will not occur if S can understand the problem and choose the right strategy in determining the unknown elements.

In general, the strategy for solving THP can be done by: (1) determining each length of the blue line segment; (2) add up the length of each segment; (3) multiplying the result by the price of steel H beam per meter; (4) conclude the funds spent to buy H beam steel.

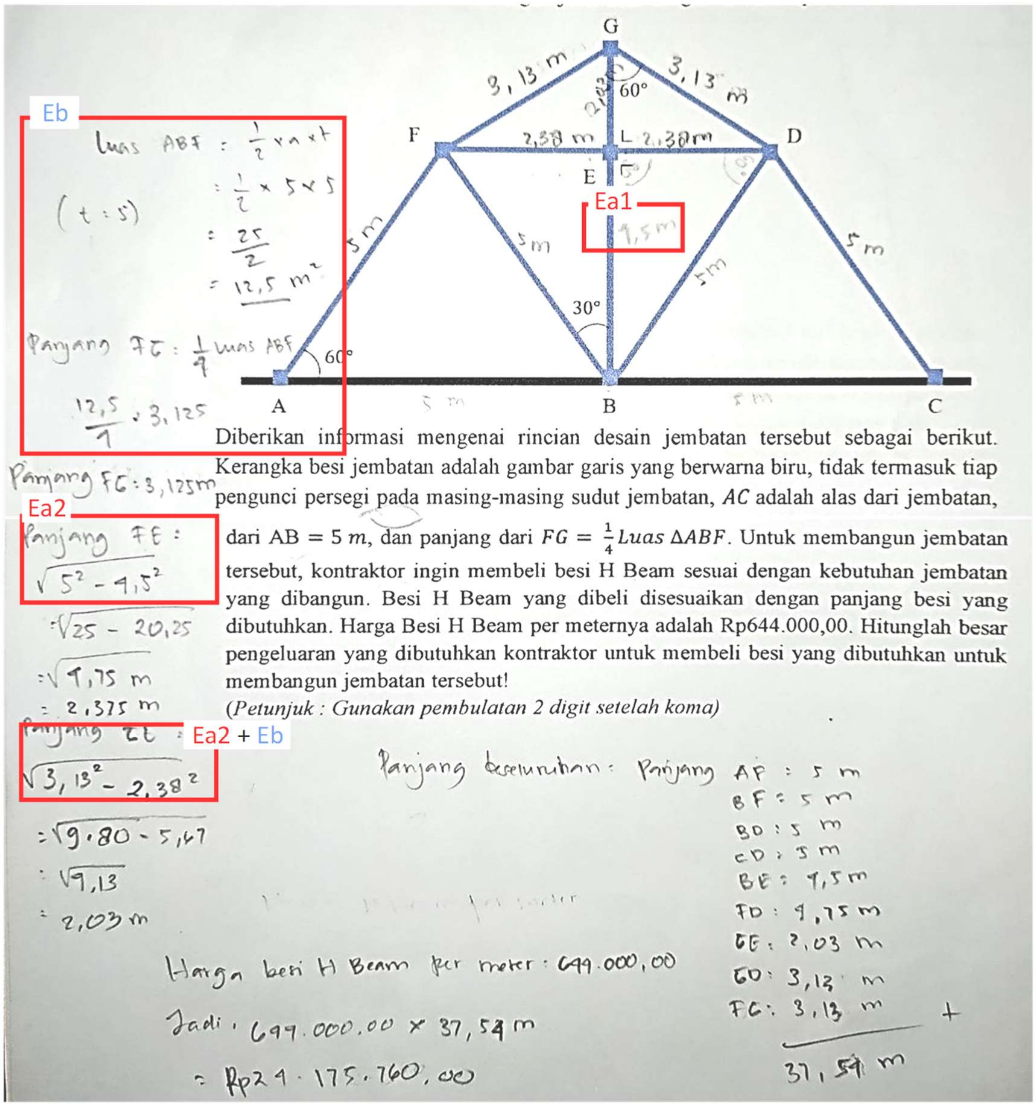


Figure 3. S work description when solving the HOT problem

There are several blue line segments that need to be searched, namely $\overline{AF}$, $\overline{BF}$, $\overline{BD}$, $\overline{CD}$, $\overline{DF}$, $\overline{FG}$, $\overline{DG}$, $\overline{BG}$. It is known that the length $\overline{AB}$ 5 meters and $\overline{FG} = \frac{1}{4}$ area ∆ABF. Since ABF≅∆BDF≅∆BDC, we get $\overline{AB} = \overline{BC} = \overline{AF} = \overline{BF} = \overline{BD} = \overline{CD} = \overline{DF} = 5$ meters. This can be seen from the large angle in each triangle, which is 60° and the length of one side is the same, namely 5 meters (considering the properties of triangles, angles, parallelograms, and kites). Based on Figure 3, S already understands if ABF≅∆BDC, but cannot find that BDF is also congruent with the two triangles (as seen from the error Ea1). S conveys that he does not think that ∆BDF is congruent with ∆ABF and ∆BDC. Therefore, S looks for length $\overline{EF}$ (error Ea2) to find length $\overline{DF}$. This should not be necessary if S understands that ABF≅∆BDF≅∆BDC.

To find the length $\overline{FG}$, consider Figure 4. Given $\overline{FG}$ = ¼ area ΔABF, then based on Figure 4, $\overline{FG}$ = ¼ × ½ × $\overline{AB} \times \overline{FP}$. It is known that $\overline{AB}$ = 5 meters, while to find $\overline{FP}$ it is necessary to apply the

Pythagorean theorem to ΔAFP atau ΔBFP. The result is $\overline{FP} = \sqrt{\overline{AF}^2 - \overline{AP}^2} = 4{,}33$ meters, so $\overline{FG} =$ ¼ × ½ ×$5 \times 4{,}33 = 2{,}71$ meters. Note that the length $\overline{FG} = \overline{DG}$, because $\Delta EFG \cong \Delta DEG$. This can be seen from the same angle and one side that is the same length. To find the length $\overline{FG}$, S has used the right method, but made an error in choosing the length $\overline{FP}$ which is 5 meters (see Eb). This choice cannot be explored because when asked, S said he forgot why he chose that length. If based on Ea1, S should be able to take the length $\overline{FP}$ 4,5 meters because $\overline{FP}$ is parallel to $\overline{BE}$. That is, S cannot find that a line can be drawn from the point F perpendicular to $\overline{AB}$ which is parallel to $\overline{BE}$.

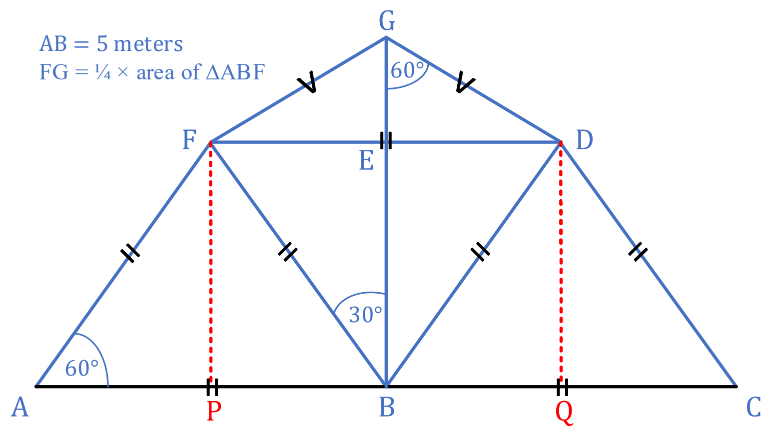


Figure 4. Solution overview from THP

The length $\overline{BG}$ can be found by adding up $\overline{BE}$ and $\overline{EG}$. $\overline{BE}$ parallel to $\overline{FP}$, then the kength $\overline{BE}$ 4,33 meters. Applying the Pythagorean theorem to ΔEFG, then $\overline{EG} = \sqrt{\overline{FG}^2 - \overline{EF}^2}$. Previously, it was explained that $\Delta ABF \cong \Delta BDF \cong \Delta BDC$, meaning that $\overline{BE}$ devides by two equal length $\overline{DF}$ so that $\overline{EF} = 2{,}5$ meters. So, $\overline{EG} = \sqrt{(2{,}71)^2 - (2{,}5)^2} = \sqrt{1{,}09} = 1{,}04$ meters. However, because S does not understand the congruence, S still performs calculations using the Pythagorean theorem on ΔBEF to find the length $\overline{EF}$. As a result, an error occurred, namely Ea2 and resulted in a further error (Ea2+Eb).

Based on the description above, taking into account Ea1, Ea2, Eb, and (Ea2+Eb) there are several main mistakes made by S, namely: (1) finding the length $\overline{BE}$ sing a ruler; (2) could not find that ΔBDF is congruent with ΔABF dan ΔBDC; (3) cannot find that a line can be drawn from point F perpendicular to $\overline{AB}$ which is parallel to $\overline{BE}$; and (4) apply the Pythagorean theorem using inappropriate components. Some of these main errors are used as the basis for categorizing error types.

Based on the results and discussion presented in the previous section, the authors collect three types of errors in solving problems made by students. The three types of errors are operational, conceptual, and principal errors (Bandura, 1977; Son, 2013). The author believes that this research has limitations. Therefore, there is a great opportunity for future research to examine the provision of interventions for students to solve problems correctly, analyze the causes of errors and design instructional methods to reduce these errors.

CONCLUSION

Based on the results and discussion presented in the previous section, the authors collect three types of errors in solving problems made by students. The three types of errors are operational, conceptual, and principal errors. The author believes that this research has limitations. Therefore, there is a great opportunity for future research to examine the provision of interventions for students in order to solve problems correctly, analyze the causes of errors and design instructional methods to reduce these errors.

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REFERENCES

Amelia, M. M. (2010). Pengaruh model pembelajaran generatif tehadap kemampuan koneksi matematika siswa.

Angriani, A. D., Nursalam, N., & Batari, T. (2018). Pengembangan Instrumen Tes Untuk Mengukur Kemampuan Koneksi Matematis. *AULADUNA: Jurnal Pendidikan Dasar Islam*, *5*(1), 1-12.

Aprilia, D., Praja, E. S., & Noto, M. S. (2018). Desain Bahan Ajar Lingkaran Berbasis Koneksi Matematis Siswa SMP. *UNION: Jurnal Ilmiah Pendidikan Matematika*, *6*(1), 43–52. https://doi.org/10.30738/.v6i1.1547

Apriyono, F. (2016). Profil Kemampuan Koneksi Matematika Siswa SMP dalam Memecahkan Masalah Matematika Ditinjau dari Gender. *Mosharafa: Jurnal Pendidikan Matematika*, *5*(2), 159-168.

Firdausi, M., Inganah, S., & Rosyadi, A. A. P. (2018). Kemampuan Koneksi Matematis Siswa Sekolah Menengah Pertama Berdasarkan Gaya Kognitif. *MaPan: Jurnal Matematika dan Pembelajaran*, *6*(2), 237-249.

Foster, F. L., & Cresap, L. (2012). *Using Reasoning Tasks to Develop Skills Necessary to Learn Independently*. Minot State University.

Hakim, A. R. (2015). Pengaruh Model Pembelajaran Generatif terhadap Kemampuan Pemecahan Masalah Matematika. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *4*(3).

Hidayat, W., & Yuliani, A. (2011). Meningkatkan Kemampuan Berpikir Kritis Matematik Siswa Sekolah Menengah Atas Melalui Pembelajaran Kooperatif Think-Talk-Write (TTW). In *Matematika dan Pendidikan Karakter dalam Pembelajaran* (pp. 535–546).

Huda, N., Tandililing, E., & Mahmudah, D. Integrasi Remediasi Miskonsepsi Dengan Model Generatif Dalam Pembelajaran Gerak Lurus Berubah Beraturan di SMA. *Jurnal Pendidikan dan Pembelajaran*, *6*(1).

Indrawati, F. (2013). Pengaruh Kemampuan Numerik dan Cara Belajar terhadap Prestasi Belajar Matematika. *Jurnal Formatif*, *3*(3), 215–223.

Irwandani, I. (2015). Pengaruh Model Pembelajaran Generatif Terhadap Pemahaman Konsep Fisika Pokok Bahasan Bunyi Peserta Didik MTs Al-Hikmah Bandar Lampung. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *4*(2), 165-177.

Lagur, D. S., Makur, A. P., & Ramda, A. H. (2018). Pengaruh Model Pembelajaran Kooperatif Tipe Numbered Head Together (NHT) terhadap Kemampuan Komunikasi Matematis. *Mosharafa: Jurnal Pendidikan Matematika*, *7*(3), 357-368.

Mawaddah, S., & Anisah, H. (2015). Kemampuan pemecahan masalah matematis siswa pada pembelajaran matematika dengan menggunakag) di smpn model pembelajaran generatif (generative learning) di smp. *EDU-MAT*, *3*(2).

Nendi, F., Mandur, K., & Makur, A. P. (2018). Pengembangan Instrumen Penilaian Kemampuan Koneksi Matematis Dalam Konsep-Konsep Matematika SMP. *Jurnal Pendidikan dan Kebudayaan Missio*, *9*(2), 165-173.

Nufus, H., & Muhammad, I. (2018). Penerapan Creative Problem Solving Berbantuan Software Autograph Untuk Meningkatkan Meningkatkan Kemampuan Koneksi Matematika Siswa. *UNION: Jurnal Ilmiah Pendidikan Matematika*, *6*(3), 369–376.

Puteri, J. W., & Riwayati, S. (2017). Kemampuan Koneksi Matematis Siswa Pada Model Pembelajaran Conneted Mathematics ProjecT (CMP). *FIBONACCI: Jurnal Pendidikan Matematika dan Matematika*, *3*(2), 161-168.

Putri, Y. N. E. (2016). Pengaruh Model Pembelajaran Generatif Terhadap Pemahaman Konsep Siswa Kelas VIII Mtsn di Kabupaten Pesisir Selatan. *Jurnal Kepemimpinan Dan Pengurusan Sekolah*, *1*(1).

Saputri, A. A., & Wilujeng, I. (2017). Developing Physics E-Scaffolding Teaching Media to Increase the Eleventh- Grade Students ' Problem Solving Ability and Scientific Attitude. *International Journal of Environmental & Science Education*, *12*(4), 729–745.

Shoimin, A. 2014. 68 Model Pembelajaran Inovatif dalam Kurikulum 2013. Yogyakarta: Ar-Ruzz Media.

Sritresna, T. (2015). Meningkatkan Kemampuan Koneksi Matematis Siswa Melalui Model Pembelajaran Cooperative-meaningful Instructional Design (C-mid). Mosharafa: Jurnal Pendidikan Matematika, 4(1), 38-47.

Sukma, Y. (2011). *Penerapan Model Pembelajaran Generatif Untuk Meningkatkan Motivasi Belajar Pendidikan Agama Islam Pada Materi Sholat Siswa Kelas III Sekolah Dasar Negeri 003 Sawah Kecamatan Kampar Utara Kabupaten Kampar* (Doctoral dissertation, Universitas Islam Negeri Sultan Sarif Kasim Riau).

Trisniawati, Muanifah, M. T., Widodo, S. A., & Ardiyaningrum, M. (2019). Effect of Edmodo towards interests in mathematics learning. *Journal of Physics: Conference Series*, *1188*, 012103.