MATHE*dunesa*
Jurnal Ilmiah Pendidikan Matematika *Volume 8 No. 2 Tahun 2019*
ISSN :2301-9085

Mathematical Representation Profile of Students in Problem Solving Based on Cognitive Styles

Mayaddah Aini Nur Azizah
Mathematics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya
e-mail: mayaddahazizah@mhs.unesa.ac.id

Raden Sulaiman
Mathematics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya
e-mail: radensulaiman@unesa.ac.id

Abstract

One of the objectives mathematics learning for students is to get the ability to solve problems which connected with their daily life. Because of the problem complexity and limitations of human thought, it is hard for human to solve the problem only with their internal ability. The methods to represents and describe their own problem of an individual might be important while solving a problem. Representation is divided into verbal representation, visual representation, and symbolic representation. One of the matters that refers to individual tendencies and individual approaches to organizing and representing is known as cognitive style. Result of this study showed that the profile of students' mathematical representation in mathematical problem solving based on cognitive style was, (1) student with Field Dependent's cognitive style could solve mathematical problems involved verbal representation in understanding the problem and making a plan; verbal representation in looking back; and symbolic representation in understanding the problem, making a plan, carrying out the plan, and looking back, (2) student with Field Independent's cognitive style could solve mathematical problems involved visual representation in understanding the problem; verbal representation in making a plan and looking back; and symbolic representation in understanding the problem, making a plan, carrying out the plan, and looking back.

Keywords: Mathematical Representation, Problem Solving, Field Dependent, Field Independent.

INTRODUCTION

One of the goals of improving the quality of learning is increasing problem solving skills. Gagne (in Purwoko, 1980) reveals that problem solving is the highest and most complex type of learning compared to other types of learning. Gagne (in Mulyasa, 2011) also states, if a student faces a problem, they not only solve the problem, but also learn something new.

Regard to problem solving and construction of new knowledge, mathematics has an important role in solving problems both in mathematics itself and other branches of science. The National Research Council (1989) said that, the success of learning mathematics would open the door to a brilliant career for a student. This explains that almost in every level of profession, mathematics must take an important role. Supported by Cahyani (2016), skill in taking part, an important aspect to be possessed by each individual in facing the ASEAN Economic Community round, is integrated through problem solving in mathematics learning activities at school.

Because of the problem complexity and limitations of human thought, it is hard for human to solve the problem only with their internal ability. In line with the statement of Neria and Amit (2004), success in the problem solving process depends on student's external representation skills involve words, graphs, tables, equations, and symbols.

One way to overcome the complexity of problem solving is through problem representation. Supported by Ellen D. Gagne & R. E. Mayer's study (in Hwang, et al, 2007), representation ability is the key to obtaining the right solution in problem solving. The way of person in representing or framing problems is a problem solving important key. Therefore, representation and problem solving are strongly related.

Unfortunately, based on the results of the Third International Mathematics and Science Study report summarized by Mullis, et al. (2015), the ability of students in Indonesia to represent mathematical ideas or concepts still low involves the material of number division, algebra, geometry, data representation, and probability analysis. This problem is one of the backgrounds to implementing 2013 curriculum to reach quality and competitive education (Kemdikbud, 2014). The low representation ability was also felt by researcher when teaching in one of the high schools in Sidoarjo. 60% of students from 5 classes were have difficulty in solving problems presented, and 50% of students had difficulty in solving problems relied on visual

and symbolic representations. Based on Hutagaol's research (2013), there was a problem in delivering mathematics material. The problem is underdeveloped representation skill of students because they have no opportunity to reveal their own representation ability in learning.

Representation is divided into external representation and internal representation (Goldin and Kaput, 1996). External representation is representation that can be observed directly include concept mapping, graphics organizing to capture patterns, relationships comparing, and other forms of external representation. While internal representation referred to the mathematical idea that allows someone's mind to work by that idea (Sabrin, 2014). The internal representation is difficult to observe directly since it was a mental activity. A person's internal representation can be inferred or suspected by observing their external representation (Andhani, 2016). In this study, the intended representation is an external representation that can be observed in plain view as a result of the mathematical ideas transformation in solving problems.

Students' problem solving skills have many variations. Besides being different in the level of problem solving skills, intelligence level, or creative thinking ability, students can also be different in how to obtain, store, and apply knowledge. The way a person process, store and use information to respond the various types of environmental situation is called cognitive style (Masriyah, 2016). Cognitive style is considered in this study since it refers to individual tendencies and individual approaches in organizing and representing (Chen, et al, 2004).

Cognitive styles that has been extensively studied are Field Dependent (FD) and Field Independent (FI). Students who are identified as FI or FD cognitive styles have different tendencies about learning, problem solving, perceiving, knowledge assimilating and remembering (Karaçam and Baran, 2015). Based on Ulya (2015) regarding to the relationship of problem solving with cognitive style, and also Udiyono & Yuwono (2018) regarding the relationship between cognitive style and learning outcomes, both showed a significant positive correlation. In this correlation, the increase of cognitive style referred to the tendency of cognitive styles toward Field Independent. The more dominant the Independent Field cognitive style of students, the better their problem solving ability.

Field Independent tends to express a picture that's free from the background of the picture and able to distinguish objects from the surrounding context more easily. In addition, they view the surrounding situation more analytically. Hence, it can be estimated that FI students are more reflective of the classification option possibilities and visual analysis of the problems faced. It's different from FD students who receive something more globally and have difficulty in separating themselves from their surroundings. FD will experience difficulties in analyzing problems and find particular difficulties in changing their strategies if needed or in using objects that are known in unusual ways (Slameto, 2010). However, in their social orientation they tend to be more perspective and sensitive.

Specific knowledge about learning and behavioral differences related to cognitive styles, helps a lot in determining how to teach students and developing different learning and teaching styles. These differences between cognitive styles in mathematics learning can be observed through the results of student representation in solving problems.

Based on the background described, the researcher decided to conduct a study about identification of student representations based on the Field Dependent and Field Independent cognitive style in solving problems. This study guided by the Polya stages (understand the problem, make a plan, carry out the plan, and look back at the completed solution) with focuses on three aspects of representation including visual, verbal, and symbolic.

METODOLOGY

This study belong to the descriptive research with qualitative approach. The objectives of this study are to describe the student mathematical representation profile in problems solving based on the Field Dependent and Field Independent cognitive style. The subjects in this study were two students of eleventh grades of Sidoarjo State High School 3 at year 2018/2019 which were selected based on the cognitive style of Field Dependent and Field Independent with control of equality of mathematical abilities and sex type. This controls uses to avoid the tendency of other factors from the students that can influence the representation of the subjects exceeding their cognitive style. Based on the objectives of the study, Group Embedded Figure Test (GEFT) and Mathematics Ability Test (TKM) were used to determine the subject. Moreover, the Problem Solving Task (TPM) and the interview guidelines was used to describe the mathematical representation profile of students in problem solving based on cognitive styles.

RESULTS AND DISCUSSION

Based on the GEFT results, two groups of Field Independent cognitive style and Field Dependent cognitive style obtained. Of the two groups, subjects were selected with the most extreme cognitive style by paying attention to the equality of TKM scores, sex type similarity, and communication skills. So that two subjects AD and JS were chosen with the following criteria.

Table 1. Research Subjects

No	Name Initial	Sex Type	GEFT Scores	Cognitive Style	TKM Score
1.	AD	Female	13	*Field Independent*	84
2.	JS	Female	4	*Field Dependent*	82

After the subject was obtained, data was collected using written methods by apply TPM, and interview methods. Figure 1 is the problem of the TPM instrument developing results.

Saat ini kamu sedang mengunjungi komplek wisata. Terdapat beberapa objek yang hendak kamu datangi yaitu sebuah bendungan, benteng tua, mercusuar dan kebun kelapa sawit. Saat ini kamu tengah berada di bendungan. Dengan bantuan selebaran peta komplek wisata dan jam tanganmu, kamu dapat melihat posisi objek-objek wisata. Kamu memposisikan bendungan sebagai titik pusat jam, dan mengarahkan jam 12 ke Utara. Dari bendungan, letak mercusuar berada pada arah jam 1, benteng berada pada arah jam 3, sedangkan kebun kelapa berada pada arah jam 8. Sebelum berangkat berwisata, kamu sudah tahu bahwa jarak bendungan ke benteng, dan jarak bendungan ke kebun kelapa sawit adalah sama yaitu sekitar 3 km. Sedangkan jarak benteng ke mercusuar adalah sekitar 4,5 km.

Tentukan lintasan paling pendek untuk mengunjungi semua objek jika kamu berangkat dari bendungan! Sertakan bukti, strategi, perhitungan, atau alasan yang kuat untuk mendukung jawabanmu!

Ilustrasi Posisi Objek-Objek Wisata

Figure 1. Problem in the TPM Instrument

After that, researcher doing data reduction. After the data is reduced, then the data will be analyzed. Hence, we obtain mathematical representation profile of students in problem solving based on cognitive styles. The following Figure 2 are the results of FI subject's work in solving problems.

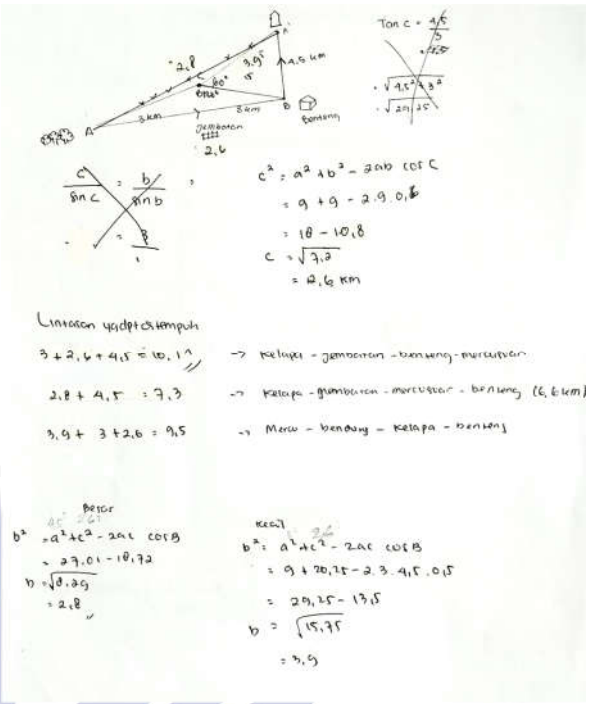

Figure 2. FI Subject Result in Solving TPM

At the stage of understanding the problem, after reading the problem, the FI subject represents visual information on the question into a simpler visual representation. The FI subject also adds alphabetic sequential variables start from A to represent certain points in her image as symbolic representations.

At the stage of making a plan, the FI subject is able to understand the implied information, so she can build an appropriate plan as symbolic representation. The FI subject writes several possible ways to solve problems as symbolic representations. FI subject uses the same variables to represent elements in a mutually independent calculation. Plans that are represented oral verbally by the FI subject are contained in the visual and symbolic representations written on her answer sheet.

At the stage of carrying out the plan, the FI subject represents symbolic in completion processes using mathematical operations, variables, and numbers. FI subject also uses verbal representation to giving tip on her calculation result.

At the stage of looking back, the FI subject represents conclusions in a symbolic representation by giving double lines below the number as the final result. The FI subject also ensures the answers she gets make sense answering questions on the questions.

The following Figure 3 are the results of FD subject work in solving problems.

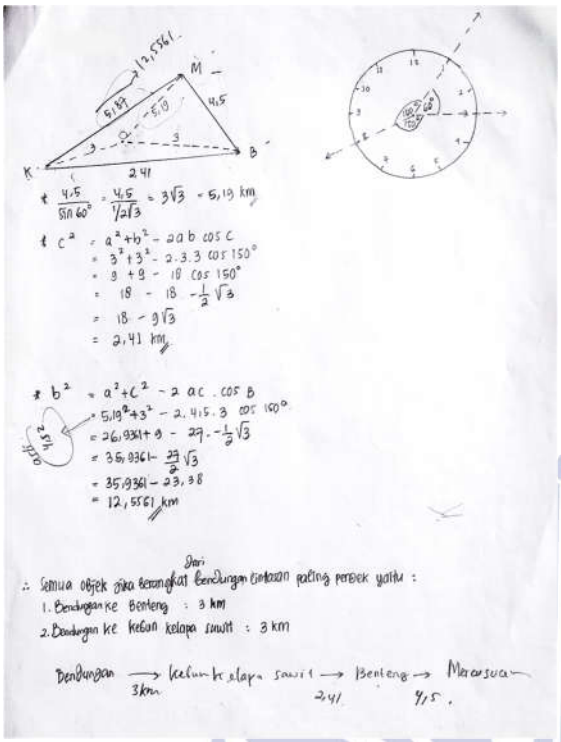

Figure 3. FD Subject Result in Solving TPM

At the stage of understanding the problem, after reading the problem, the FD subject presents visual information on the question into a visual form as two images which showing two separate information. FD subjects also uses symbolic representations involve variables that represent certain points. The variable is taken based on the initials of the object name.

At the stage of making a plan, FD subject writes her plan symbolically based on visual information on the questions. However, the subject did not understand the information implied in the picture so there were errors in the use of mathematical rules. FD subject only writes one possible plan. FD subject uses the same variables to represent elements in a mutually independent calculation. Plans that represented verbally by FD subject are more detailed than the visual and symbolic representations written on her answer sheet.

At the stage of carrying out the plan, the subject FD represents the completion process in symbolic form involve operations, variables, and numbers. Subject FD also uses verbal representation as one of the completion stages.

At the stage of looking back, the FD subject represents conclusions in symbolic form by giving two lines below the final result. The FD subject also checks the number in the calculation, to ensure that the number substituted is right.

In accordance with Slameto (2010), FI is better able to distinguish objects apart from it background of the surrounding context. This can be seen from the way the FI subject understands two different information into one. Moreover, the FI subject also symbolizes an object with a variable separated from the actual object name. In another hand, FD subject presents images similar to the given information and needs to separate the two informations first to find out the point of each information. FD subject also symbolizes an object with a variable related to the name of the original object. The representation of the FD subject is related to the statement of Wooldridge and Haimes-Bartolf (2006) which states that an FD tends to have difficulty separating an implied information from the surrounding situation.

Inside the oral verbal representation of FI in explaining her plan in solving problems, subject tells the plan corresponding to the steps in written work. Hence, there is a match between written representation and verbal representation. The FD subject tells her plan in oral verbal representation more detail than her written work.

CLOSING

Conclusion

In each stage of problem solving, FI and FD students represent ideas differently. Student with Field Dependent's cognitive style could solve mathematical problems involved verbal representation in understanding the problem and making a plan; verbal representation in looking back; and symbolic representation in understanding the problem, making a plan, carrying out the plan, and looking back. Student with Field Independent's cognitive style could solve mathematical problems involved visual representation in understanding the problem; verbal representation in making a plan and looking back; and symbolic representation in understanding the problem, making a plan, carrying out the plan, and looking back.

Suggestions

Based on the research that has been done, the researchers concluded that the following cases need to be considered are (1) for further research, quantitative research is conducted to determine the effect of cognitive style on student representation in problem solving so that research related to student representation, problem solving, and cognitive style can be more useful for the development of learning activities; (2) it is recommended for other researchers in similar qualitative research to triangulate for the validity and reliability of the data obtained; and (3) in the development of the Problem Solving Task instrument, it is recommended to arrange questions with contexts that do not require too difficult mathematical concepts, but still can explore mathematical representation of students in solving problems.

REFERENCES

Andhani, Rista Ayu. 2016. "Representasi Eksternal Siswa dalam Pemecahan Masalah SPLDV Ditinjau dari Kemampuan Matematika". *Jurnal Matematika Kreatif Inovatif (KREANO).* Vol. 7 (2) : hal. 179-186.

Cahyani, Hesti, dan Setyawati, Ririn Wahyu. 2016. "Pentingnya Peningkatan Kemampuan Pemecahan Masalah melalui PBL untuk Mempersiapkan Generasi Unggul Menghadapi MEA". *Seminar Nasional Matematika X Universitas Negeri Semarang 2016*. Hal 151-160.

E. Mulyasa. 2011. *Menjadi Guru Profesional Menciptakan Pembelajaran Kreatif dan Menyenangkan.* Bandung : PT. Remaja Rosdakarya.

Goldin, G,A. dan Kaput, James J. 1996. "A Joint Perspective On The Idea Of Representation In Learning And Doing Mathematics". Dalam Steffe, L. P., Nesher, P., Cobb, P., Goldin, G. A., & Greer, B. *Theories of Mathematical Learning* (pp. 397-430). Mahwah, NJ: Erlbaum.

Hutagaol, Kartini. 2013. "Pembelajaran Kontekstual Untuk Meningkatkan Kemampuan Representasi Matematis Siswa Sekolah Menengah Pertama". *Infinity: Jurnal Ilmiah Program Studi Matematika STKIP Siliwangi Bandung*, Vol 2 (1) : hal 85-99.

Hwang, W.Y., N.S Chen., J.J. Dung, Y.L. Yang. 2007. "Multiple Representation Skills and Creativity Effects on Mathematical Problem Solving using a Multimedia Whiteboard System". *Educational Technology & Society*. Vol.10 (2) : pp 191-212.

Karaçam, Sedat and Baran, Azize Digilli. 2015. "The effects of field dependent/field independent cognitive styles and motivational styles on students' conceptual understanding about direct current circuits". *Asia-Pacific Forum on Science Learning and Teaching.* Vol. 16, Issue 2 (6) : pp 1-19.

Kementerian Pendidikan dan Kebudayaan. 2014. "Konsep dan Implementasi Kurikulum 2013". *Paparan Wakil Menteri Pendidikan dan Kebudayaan R.I Bidang Pendidikan, Jakarta, 14 Januari 2014.*

Masriyah, dan Hanifah, Umi. 2016. "Number Sense Siswa Smp Ditinjau Dari Gaya Kognitif". *Prosiding Seminar Nasional Pendidikan Matematika 2016*. Hal. 38-54.

Miles, Matthew B., A. Michael Huberman, Johnny Saldana. 2014. *Qualitative Data Analysis.* USA: SAGE Publication, Inc.

Mullis, Ina V.S., Michael O. Martin, Pierre Foy, Martin Hooper. 2015. *TIMSS 2015: International Results in Mathematics*. Boston: Lynch School of Education.

Nasution, S. 2006. *Berbagai Pendekatan Dalam Proses Belajar & Mengajar.* Jakarta: Bina Aksara.

National Council of Teacher of Mathematics. 2000. *Principles and Standars for School Mathematics*. America: NCTM.

National Research Council. 1989. *Everybody Counts: A Report to the Nation on the Future of Mathematics Education*. Washington DC: National Academy Press.

Neria, Dorit and Amit, Miriam. 2004. "Students preference of non-algebraic representations in mathematical communication". *In Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education*.Vol. 03 : pp 409-416.

Polya, George. 1962. *Mathematical Dsicovery: Understanding, Learning, and Teaching*. New York: John Wiley & Sons.

Purwoko. Tanpa tahun. *Pembelajaran Matematika Sekolah Dasar Unit 3: Teori Belajar Gagne*,(Online),(Tersedia di http://staff.uny.ac.id/sites/default/files/ PengembanganPembelajaranMatematika_UNIT_3_0.pdf. Diakses 2 Desember 2018).

Rahaju, Endah Budi. 2016. *Porses Berpikir Siswa SMP Ditinjau Berdasarkan Gaya Kognitif dalam Pemahaman Konsep Segiempat.* Disertasi tidak diterbitkan. Surabaya: Universitas Negeri Surabaya.

Slameto. 2010. *Belajar dan Faktor-Faktor yang Mmepengaruhi.* Jakarta: PT Rineka Cipta.

Udiyono dan Yuwono, M. R. 2018. "The Correlation between Cognitive Style and Students' Learning Achievement on Geometry Subject". *Infinity: Journal of Mathematics Education*. Vol. 7 (1) : pp 35-44.

Ulya, Himmatul. 2015. "Kognitif Dengan Kemampuan Pemecahan Masalah Matematika Siswa". *Jurnal Konseling GUSJIGANG*. Vol. 1 (2).

Witkin, H. A., Goodenough, D. R., & Karp, S. A. 1967. "Stability Of Cognitive Style From Childhood To Young Adulthood". *Journal of Personality and Social Psychology*. Vol. 7(3, Pt.1) : pp 291-300.

Wooldridge, Blue, and Haimes-Bartonf, Melanie. 2006. "The Field Dependence/Field Independence Learning Styles: Implications for Adult Student Diversity, Outcomes Assessment and Accountability". Sims, Ronald R., and Sims, Serebrenia J. (Ed). *Learning Styles and Learning: A Key to Meeting the Accountability Demans in Education.* New York: Nova Science Publishers, Inc.