

An Analysis of Students' Error in Learning Mathematical Problem Solving: The Perspective of David Kolb's Theory

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Abstract: One of the urgencies of mathematics learning is how much students' ability to solve mathematical problems. But in the process, not a few students who make mistakes in doing math tests. In addition, it turns out that various types of errors also depend on the learning style possessed by students. then the focus of this research is to analyze students' errors in solving mathematical problems based on differences in learning styles according to David Kolb's theory. The study was conducted at the Vocational Middle School in Cirebon-Indonesia. the type of research used is a qualitative research case study approach. The instrument used in this study was a questionnaire (Kolb Learning Style Inventory refers to KLSI version 3.1) and tests. Whereas for the analysis of research data using triangulation techniques. The results show that there is a proportional diversity of students' learning styles. each type of learning style has its own unique errors. where the type of diverger is procedural error and misunderstanding. The types of assimilator type errors are procedural and conceptual errors, the type of convergent error type is a procedural error. The type of accommodator type error is a conceptual error. so the type of conceptual is caused by the wrong understanding or deviated from the existing provisions, so this affects the students to make mistakes in the process of math tests. Strategy errors can be experienced when the students are stuck to continue the process of completing a math test. procedural errors occur when the system uses a method that is not systematic in completing the test.

1 INTRODUCTION

Mathematics learning is about the concepts and structures of mathematics contained in the material being studied, as well as finding the relationship between concepts and mathematical structures in them (Bruner, 2017; Hiebert and Lefevre, 1986). Furthermore, mathematics learning can also be interpreted as a learning process that actively involves students to build mathematical knowledge (Voigt, 2013). Therefore the learning of mathematics itself is a process of interaction between teachers and students which implies the development of thinking models and elaboration logic in the learning environment. The condition is created by teachers with various methods so that the learning activities of mathematics can grow and develop optimally and students can carry out the learning activities effectively and efficiently.

The purpose of learning mathematics itself consists of; (a) Train thinking and reasoning in drawing conclusions, for example through exploration, experimentation, equality, diversity, consistency, and inconsistency; (b) Developing creative activities

involving imagination, intuition, and discovery by developing divergent, original thinking, curiosity, making predictions and guesswork, and experimenting; (c) Develop problem-solving skills; (d) Developing the ability to convey information or communicate ideas through spoken speech, charts, maps, and diagrams in explaining ideas (Schoenfeld, 2016).

Seeing how important mathematics is, it becomes ironic in the fact that many students do not like mathematics (Hannover and Kessels, 2004; Tirta Gondoseputro, 1999). Students assume that math is a lesson that less favorable. According to survey data, mathematics occupies the third position as the subjects most hated by students (Rofalina, 2015). Meanwhile, based on data from PISA (The Program for International Student Assessment) in 2015, states that the performance of Indonesian students is still relatively low. Successively average Indonesian achievement scores for science, reading, and math are ranked 62, 61, and 63 of the 69 countries evaluated. The ratings and average Indonesian score do not differ much from previous PISA tests and surveys in

2012 which are also in the low material mastery group (Stacey, 2015).

Based on the data, students' ability in understanding mathematics is very low. The ability of students in solving mathematical problems can be known through the tests given when the evaluation of mathematical learning. In the process of mathematics learning, students often make mistakes. The number of mistakes made in working on mathematical problems into a hint of the extent to which student mastery of the material. From the mistakes made, it can be further investigated about the source of errors committed by students. The cause of the mistakes made by the student should immediately get a complete solution. This solution is done by analyzing the root cause of the error, and afterward identified the types of mistakes that are commonly done by students in crafting math tests.

The mistakes made by students are obstacles to learning mathematics. According to Taylor Koriakin, et al error is a form of deviation from the right, pre-determined procedural or deviation from an expected (Taylor, Bogdan and DeVault, 2015). Identifies the type of miscalculation of the count operation performed by the student (Mercer and Mercer, 1989). The types of mistakes made by students are divided into operating errors, computational errors, algorithmic errors, and random answers. This is similar to what is described by Radatz, there are 3 indicators of the type of error that is: a) misconceptions, mistakes made by students in using the concepts related to the material, b) Errors of principle, errors in using the rules or mathematical or incorrect formulas in the use of principles relating to the material, c) Operational error, errors in operation or calculation. Certainly, the student's mistake will have an impact on the outcome of the learning process (Radatz, 1980).

The factors that influence student learning outcomes are two factors, among others internal factors, namely the lack of special talent in doing certain situations, lack of basic skills possessed by students, lack of motivation and motivation to learn and physical factors which does not support learning activities (Lim and Morris, 2009). Another factor is about how the character of students in the learning process, as well as learning styles owned by each student. Mistakes in mathematical problem solving can also be observed from student learning styles (Ryan and Williams, 2007). In line with that opinion, Eugene A Geist, and Margaret King suggests that students' mistakes can be seen from the student's learning style, of course, because every individual has different characters, so in the case of any questions

the factors can cause students to make mistakes (Geist and King, 2008).

Learning styles are a combination of how one absorbs, and then organizes and processes information (Schmeck, 2013). Learning styles are not just aspects of facing information, seeing, listening, writing and saying but also the aspect of information processing, analytical, global or left-brain right brain, another aspect is when responding to something in the learning environment (abstractly and concretely absorbed). This is in line with the view of Riding & Rayner, which suggests a student learning style that is the consistent way in capturing stimulus or information, how to remember or think and solve problems (Riding and Rayner, 2013). Learning styles are the way students tend to react and use incentives to absorb and then organize and process information in the learning process.

David Kolb's learning model is a learning style that involves new student experiences, develops observation/reflection, drafts, and uses theories to solve problems. Student learning styles are influenced by personality types, habits, and develop over time and experience. The model is built on the idea that learning preferences can be explained by the active observations of experiments-reflections and experiences of abstract concrete concepts. The result is that there are four types of learners: convergent (experimental experimental-abstract), accommodator (experimental - active experience), assimilation (conceptualization of abstract - reflective observation), and divers (reflective viewing experience) (Kolb, 1981).

Based on observations in one of the Vocational High Schools, many students complained that they had difficulty in understanding math problems. The mathematics whose primary purpose is to form students with the first critical, logical and systematic ability is fortified with the mathematical fears themselves. In addition, mathematics teachers argue that during this time students have a variety of learning styles that have not been known for sure, of course, this is correlated with the learning process conducted in the classroom. Thus, the researchers are interested in learning styles according to David Kolb's theory. where individual differences are mapped into different types of learning styles.

Observing the problem, in previous studies have not paid attention to the analysis of student errors on differences in learning styles that students have. In addition, the analysis of student error in solving mathematical problems can be detected through the answers to exercise questions. Thus, researchers are encouraged to analyze student errors.

2 METHODS

Based on the objectives to be achieved in this study, namely to analyze student errors. then the type of research used is qualitative with case study approach (Taylor, Bogdan and DeVault, 2015; Creswell and Creswell, 2017). it is necessary to acquire knowledge or solve problems encountered and carried out carefully and systematically and can give a specific picture of the problem.

2.1 Procedure

This research was conducted at SMK Patriot Cirebon with the subject of the research of students class X. The research subjects were grouped according to the learning style according to the theory of David Kolb. Selection of subjects based on the following criteria: a) Students who complete the math test with the most questions and b) Students who make more mistakes in working on math problems. While the object of the research is students error make in solving math problems. The math test was performed using the system of linear equations with two variables (SPLDV).

2.2 Data Collection and Analisis Technique

The tools used in this study are questionnaires and tests (Cohen, Manion and Morrison, 2013). The questionnaire and the test tools, both created and developed by the author. The questionnaire development process adopted the Kolb Learning Style Inventory concept and refers to KLSI version 3.1 (Kolb, 1976; Manolis *et al.*, 2013). There are 48 items used in the questionnaire. The 12 grains represent the dimensions of the CE (Concrete Experience), 12 elements describe the dimensions of RO (Reflective Observation), 12 items describe the dimensions of AC (Abstract Conceptualization) and 12 items describe the size AE (Active Experimental). The test used in this study is a test essay (Mohamad *et al.*, 2015). The grid of this evaluation of the essay uses the achievement of the learning of the system of linear equations with two variables (SPLDV). The reference used in the preparation of this essay adopts the cognitive aspects of Bloom's taxonomy, namely the categories C4, C5 and C6 (Bloom, 1956). While for data analysis, using the triangulation technique (Leech and Onwuegbuzie, 2007).

3 RESULTS AND DISCUSSION

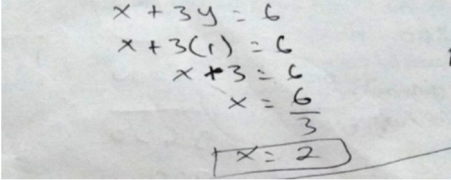
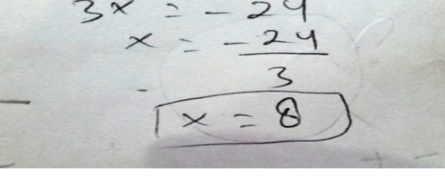
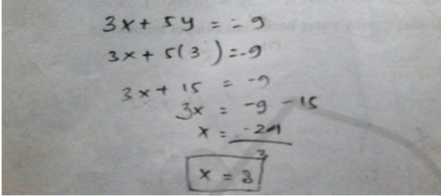
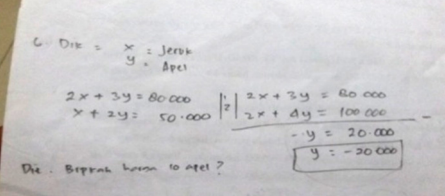
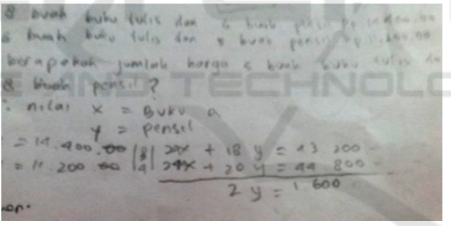
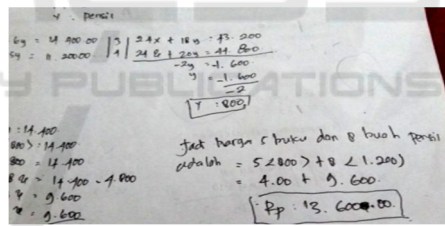
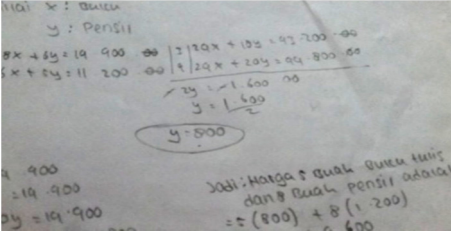
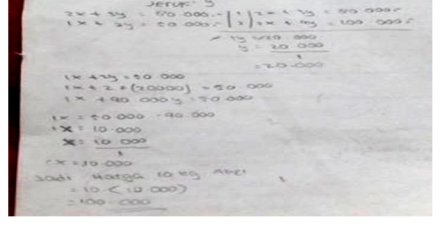
The first stage in this study was to classify the learning styles of students. Based on the results of the questionnaire distribution Kolb Learning Style Inventory to 24 class X students of Cirebon Patriot State Vocational School, the grouping of learning styles was obtained as follows.

Table 1: The Proportion of Student Learning Styles

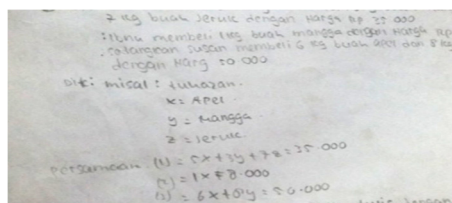
Type of Learning Style	(%)	Subject Code
Diverger	12,5	PM04, PM18, PM19
Assimilator	16,7	PM01, PM11, PM14, PM22
Converger	33,3	PM02, PM03, PM05, PM07, PM09, PM16, PM20, PM21
Accommodator	37,5	PM6, PM8, PM10, PM12, PM13, PM15, PM17, PM23, PM24

Based on Table 1. Type of the more dominant accommodator (37.5% of students). While the Diverger type is less than four other learning styles (12.5% of students). After classifying students based on the Kolb modeling style, only a total of eight subjects were eligible for further analysis. Then the subject of the study was given a math test to find out what kind of error occurred. The following in the second stage in this study dissects several cases of errors made by students based on differences in learning styles.

Tabel 2: Characteristics of Student Error in Learning Mathematical Problem Solving

Type of Learning Style	Students' answers and errors in problem-solving	
Diverger	<p>PM04 Answer no 1</p> 	<p>Answer no 3</p> 
	<p>The subject of PM04 encountered an error on the use of the number operation sign, this is due to the inability of the subject to solve the problem.</p>	<p>The subject of PM04 also performs procedural errors in terms of division of positive and negative numbers</p>
	<p>PM18 Answer no 3</p> 	<p>Answer no 6</p> 
	<p>Subject PM18 performs on erroneous operation number</p>	<p>Subject PM18 has two operation count errors in integers</p>
Assimilator	<p>PM01 Answer no 4</p> 	<p>PM22 Answer no 4</p> 
	<p>Subject PM01 made a mistake that does not work the completion process to completion</p>	<p>Subject PM22 made an error in placing the variable</p>
Converger	<p>PM03 Answer no 4</p> 	<p>Answer no 6</p> 
	<p>Subject PM03 performs in placing variables x and y</p>	<p>The subject of PM03 makes error that is wrong in determining the variables x and y</p>

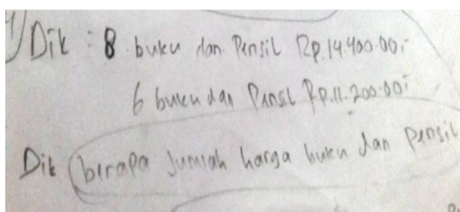
Answer no 8



The subject of PM03 made a mistake in transforming the story into the form of mathematical modeling

PM07

Answer no 4

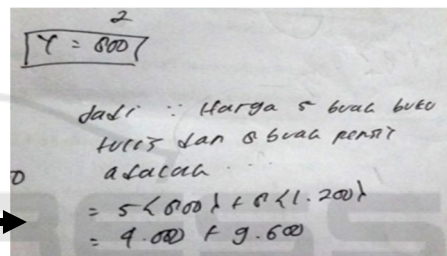
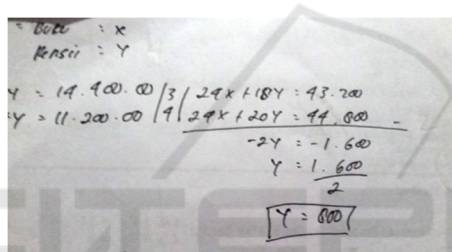


Subject PM07 made a mistake not to do the work to completion, other than that the subject also made a redaction error

Accommodator

PM08

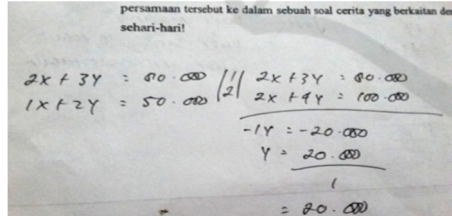
Answer no 4



The subject of PM08 has errors in the procedure that is wrong in entering the data that has been known

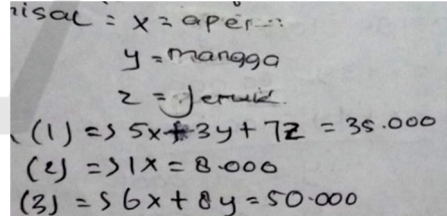
PM24

Answer no 6



The subject of PM24 encountered an error for not continuing the work

Answer no 8



The subject of PM24 has an error in placing the variable

Based on table 2. The next study continued with the third stage, namely classifying the types of student errors. Explanation will describe the type of student errors that are made and provide an explanation of the factors that cause student errors. The detailed explanation as follows.

Type of conceptual error-The first type of error students make is a conceptual error. According to James Hiebert and Patricia Lefevre, a conceptual error is a mistake in determining and using the theorem or answering the problem (Hiebert and

Lefevre, 1986). Correspondingly, Sahriah (2012) explains that the conceptual error indicator includes: a) wrong in determining formula or theorem or definition to answer the problem; b) incorrect use of formulas, theorems or definitions which are inconsistent with the conditions under which formulas, theorems or definitions apply; and c) incorrectly not writing formulas, theorems or definitions to answer the problem (Riccomini, 2005).

The conceptual error is done by the subject of PM08, PM22, and PM24. The subject of PM08 makes

the mistake of not changing the known information to the definition to make it easier to the next stage. Subjects in the stage of creating mathematical equations without making variables available. This causes the subject to not complete the job. Based on the interview, the subject did not quite understand that he made a mistake. The subject of PM22 misinterpreted the problem at number 4, the subject answered does not match the existing or already taught definition. The subject does not yet understand correctly, but the subject takes the initiative to solve the problems he faces by creating his own theory. Interview results state that the concept known to the subject is a searched variable first. but the concept is wrong, so make the subject make a mistake.

This case also occurs on the subject of PM24, not understanding the existing material makes the subject create his own theory based on his feelings. The subject experienced an error when turning the story into a mathematical modeling. In the interview quote, the variable equation should start from the variable (x) without considering the information contained in the problem or regardless of the occupation that has been occupied. The subject has a misconception about the concept. So it made him make a mistake.

So, conceptual mistakes are errors that are made because of wrong understanding or deviate from the existing provisions, so this affects a person to make mistakes in the process of workmanship. The indicators of conceptual error are a) wrong in changing the problem into a mathematical equation; b) wrong in using data.

Type of strategy errors-The second type of errors students make is a strategy errors. According to Nancy C. Jordan and Teresa Oettinger Montani, a strategy error is an error that occurs if the student chooses an inappropriate path and leads to a deadlock path (Jordan and Montani, 1997). This is related to what Ivan Watson said, that the category of errors in problems is related to the problem of hierarchy of skills(Watson, 1980).

The strategy error is done by PM18 subject. Subject PM18 basically make a mistake on operation number, where the answer obtained results for apple unit price is Rp. -20,000. The subject is aware of the error because there is no rupiah value that is negative. But the subject does not have the motivation to re-check, so, with the beginning of the process is wrong, the subject experience deadlock, the subject prefers not to solve the problem where it affects the final result. Thus, a strategy error is an error in the process experienced by someone experiencing a deadlock to continue the settlement process.

Type of procedural error -The third type of errors students make is a procedural error. a procedural error is an error in preparing the steps. Further explained, procedural error indicator is: a)

wrong not write problem in process of settlement; b) incorrectly discontinuing the settlement process; c) wrong in understanding and observing the purpose of the question; d) wrong in performing addition and subtraction operations; e) wrong in multiplication and distribution operations; f) incorrectly unable to manipulate steps; g) is false for concluding without reason; and h) false because the settlement step is not systematic (Rittle-Johnson and Alibali, 1999).

The procedural error is done by a subject of PM01, PM03, PM04, and PM07. The subject of PM01 encountered an error because it did not complete until the final process. Subject understands concepts and solutions but does not solve them due to environmental factors (disturbed concentration). Still, this has an impact on errors in solving a problem. The subject of PM03 makes a mistake in placing the variables (x) and (y). But this is based on no reason, not because it has its own concept. But the cause is because the subject still does not understand the material that is complex.

The subject of PM04 makes an error in the operation of integers. Of the two questions resolved by the subject, both are the same in the type of error that is caused by the crowd around him that makes him unable to focus.

The subject of PM07 has an error in looking at the problem. The information written by PM07 does not match what is asked in the question. This is because the physical condition is being experienced by the subject so as to make it not careful with what is asked.

Thus, a procedural error is an error in using an unsystematic way to perform a settlement that affects the outcome. The procedural error indicator is a) wrong not writing down what is known and asked; b) wrong does not solve the problem to the end; c) wrong in the placement of known data; d) wrong in counting operations that impact on the final result.

4 CONCLUSIONS

Starting from the discussion of the previous chapter, the authors present some conclusions as follows; Student learning styles in SMK Patriot Cirebon vary greatly. Based on David Kolb's theories used in this study, the distribution of learning styles of students as follows: there are three students who have divergent type learning style, 4 students have learning style of assimilation type, 8 students have Converger style learning style, and 9 students have of learning style the accommodator. Types of errors made by diverger types are procedural errors and misconceptions, Types of assimilator type errors are procedural and conceptual errors, Types of converger type errors are

procedural errors. The type of accommodator type error is a conceptual error. Furthermore, the data show that there are three types of errors made by students in completing the math test. The three types are; 1) The errors of the first type is the conceptual error, where the error is done because of a wrong understanding or deviated from the existing provisions, so this affects the students to make errors in the process of math tests. 2) The second type of mistake is a strategy error, experienced because students are stuck to continue the process of completing the math test. and 3) The third type of error is a procedural error, an error in using an unsystematic way to perform a settlement that impacts the final result of the test

5 REKOMENDATIONS

To overcome the obstacles found at the time of the study, the authors propose some recommendations as follows: The teacher must determine the comprehensiveness of the material understanding of the student's mathematical achievement. Furthermore, teachers should also familiarize students with systematic issues. While suggestions for students, students should often practice elaboration of complex mathematical tests and practice solving math problems in a systematic and effective way.

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REFERENCES

- Bloom, B. S. (1956) *Taxonomy of educational objectives*. New York City: McKay.
- Cohen, L., Manion, L. and Morrison, K. (2013) 'The ethics of educational and social research', in *Research methods in education*. London: Routledge, pp. 99–128.
- Creswell, J. W. and Creswell, J. D. (2017) *Research design: Qualitative, quantitative, and mixed methods approaches*. New York City: Sage publications.
- Geist, E. A. and King, M. (2008) 'Different, not better: gender differences in mathematics learning and achievement', *Journal of Instructional Psychology*, 35(1), pp. 43–52.
- Hannover, B. and Kessels, U. (2004) 'Self-to-prototype matching as a strategy for making academic choices. Why high school students do not like math and science', *Learning and instruction*, 14(1), pp. 51–67.
- Hiebert, J. and Lefevre, P. (1986) 'Conceptual and procedural knowledge in mathematics: An introductory analysis', in *Conceptual and procedural knowledge: The case of mathematics 2*. London: Routledge, pp. 1–27.
- Jordan, N. C. and Montani, T. O. (1997) 'Cognitive arithmetic and problem solving: A comparison of children with specific and general mathematics difficulties', *Journal of learning disabilities*, 30(6), pp. 624–634.
- Kolb, D. A. (1976) *Learning style inventory technical manual*. Boston: MA: McBer.
- Kolb, D. A. (1981) 'Learning styles and disciplinary differences .', in *The modern American college 1*, pp. 232–255.
- Leech, N. L. and Onwuegbuzie, A. J. (2007) 'An array of qualitative data analysis tools: a call for data analysis triangulation 557.', *School psychology quarterly*, 22(4), pp. 557–584.
- Lim, D. H. and Morris, M. L. (2009) 'Learner and instructional factors influencing learning outcomes within a blended learning environment', *Journal of Educational Technology & Society*, 12(4), pp. 282–293.
- Manolis, C. et al. (2013) 'Assessing experiential learning styles: A methodological reconstruction and validation of the Kolb Learning Style Inventory', *Learning and individual differences*, 23, pp. 44–52.
- Mercer, C. D. and Mercer, A. R. (1989) *Teaching students with learning problems*. United States: Merrill Publishing Co.
- Mohamad, M. M. et al. (2015) 'Measuring the validity and reliability of research instruments', in *Procedia-Social and Behavioral Sciences 204*, pp. 164–171.
- Radatz, H. (1980) 'Students' errors in the mathematical learning process: a survey', *For the learning of Mathematics*, 1(1), pp. 16–20.
- Riccomini, P. J. (2005) 'Identification and remediation of systematic error patterns in subtraction', *Learning Disability Quarterly*, 28(3), pp. 233–242.
- Riding, R. and Rayner, S. (2013) *Cognitive styles and learning strategies: Understanding style differences in learning and behavior*. United Kingdom: David Fulton Publishers.
- Rittle-Johnson, B. and Alibali, M. W. (1999) 'Conceptual and procedural knowledge of mathematics: Does one lead to the other?', *Journal of educational psychology*, 91(1), pp. 175–189.
- Rofalina, F. (2015) *Infografik: Pelajaran Paling Disukai dan Dibenci Siswa Indonesia, Zenius Net*.
- Ryan, J. and Williams, J. (2007) *Children'S mathematics 4-15: learning from errors and misconceptions: learning from errors and misconceptions*. United States: McGraw-Hill Education (UK).
- Schmeck, R. R. (2013) *Learning strategies and learning styles*. Germany: Springer Science & Business Media.
- Schoenfeld, A. H. (2016) 'Learning to Think Mathematically: Problem Solving, Metacognition, and

- Sense Making in Mathematics', *Journal of Education*, 196(2), pp. 1–38.
- Stacey, K. (2015) 'The international assessment of mathematical literacy: PISA 2012 framework and items', in *The 12th International Congress on Mathematical Education*. United States: Springer New York LLC, pp. 771–790.
- Taylor, S. J., Bogdan, R. and DeVault, M. (2015) *Introduction to qualitative research methods: A guidebook and resource*. New York City: John Wiley & Sons.
- Tirta Gondoseputro, T. (1999) 'The cross-cultural perspective of teachers' beliefs and their influence on teaching practices: A case study of two teachers teaching secondary mathematics in Australia and Indonesia', in *Making the difference: Proceedings of the Twentysecond Annual Conference of The Mathematics Education Research Group of Australasia Incorporated*, pp. 494–501.
- Voigt, J. (2013) 'Negotiation of mathematical meaning in classroom processes: Social interaction and learning mathematics', in *Theories of mathematical learning*. Routledge, pp. 33–62.
- Watson, I. (1980) 'Investigating errors of beginning mathematicians', *Educational Studies in Mathematics*, 11(3), pp. 319–329.

