Students’ understanding of mathematical concepts and their self-confidence through a discovery learning model

Y K Maifi¹, Anwar¹ and A Ahmad²

¹ Department of Mathematics Education, Syiah Kuala University, Banda Aceh, 23111, Indonesia
² Department of Early Childhood Education, Syiah Kuala University, Banda Aceh, 23111, Indonesia

E-mail: anwarramli@unsyiah.ac.id

Abstract. This study aims to describe students’ understanding of mathematical concepts and self-confidence after implementing the discovery learning model. This study used a qualitative approach with a descriptive type. The participants were four seventh-grade students in one of the junior high schools in Meukek, South Aceh. The instruments used in this study were conceptual understanding tests and a self-confidence questionnaire. Data analysis involved data reduction, data presentation, and drawing conclusions. The results revealed that students’ understanding of mathematical concepts and self-confidence became better after implementing the discovery learning model. The student who initially possessed a low understanding of mathematical concepts had the medium category after learning with the discovery learning model. Out of six indicators of understanding mathematical concepts, four indicators had been fulfilled by students. However, students were still deficient in the indicators of presenting concepts in various representations and linking various mathematical concepts internally or externally. With respect to self-confidence, the findings showed that students met the indicators of act independently in making decisions, good self-concepts, and dare to express opinions, but they still lacked the indicator of believing in their abilities.

1. Introduction
Mathematics is a subject studied at every level of education. Students are required to have cognitive (knowledge) and affective (attitudes) [1-4]. One of the essential cognitive factors in mathematics is an understanding of mathematical concepts. This statement aligns with a study stating that understanding important concepts should be owned by every student who learns mathematics [5-6]. Conceptual understanding refers to a student's ability to master some subject matters, where students know or remember some concepts being learned and can express them in other easily understandable forms [7].

One of the affective factors needed in mathematics learning is self-confidence [1]. Self-confidence is crucial for students in learning mathematics [8-9] as it helps students succeed in learning [10]. Self-confidence is an attitude or feeling about our own abilities. A person with good self-confidence will not be anxious in his actions, have the freedom to do things he desires, be responsible for his actions, interact with others politely and friendly, respect others, be persistent to achieve goals, and recognize his strengths and weaknesses [11-12]. Self-confidence is an attitude of believing in his own abilities and seeing himself as a whole person by self-concept [13]. Self-confidence in mathematics learning
can be described as students’ belief about self-competence in mathematics and ability in learning mathematics [14-15].

In fact, several previous studies have found that students’ conceptual understanding is still relatively low. This insufficient understanding occurs because teachers focus more on steps or procedures students use to solve math problems instead of why they use the procedure [16]. This also happens when the teachers actively provide information and use a one-way interaction in teaching [17]. In learning the concept, students should not be limited to one source only. Instead, students are directed to find information from various sources [18-19]. Besides, the students’ self-confidence remains low. Many students are passive during the learning process. When the teacher asks a question, students look nervous and hesitant to respond, resulting in poor student learning outcomes [20-21]. The students’ insufficient understanding of solving math problems is also caused by their self-confidence [22]. Out of seven students being studied, five students performed low self-confidence [23].

Therefore, a learning model is needed to help students participate actively in the learning process in order to increase their understanding of mathematical concepts and build their self-confidence. A learning model that can stimulate students to work actively and to discover their own concepts is the discovery learning model. Discovery learning is learning that focuses on the intellectual minds of students in solving various problems to help them find a concept or generalization applied in real situations [24-27]. Discovery learning is a learning model where students build their knowledge by conducting an experiment and discovering a principle from the results of the experiment [28-29]. Discovery learning is designed in a way that students can discover concepts and principles through their mental processes [30]. In other words, students follow several stages of discovery learning, directing them to get the stage of discovering new concepts. The Discovery learning model has six stages: stimulation (giving stimulation), problem statement (problem identification), data collection, data processing, verification (proof), and generalization [31-32].

Research on students’ conceptual understanding and self-confidence with the discovery learning model in mathematics has been conducted [11]. It revealed that if students have a good conceptual understanding, then their self-confidence becomes good as well. Meanwhile, not all students have a good comprehension of mathematics, and even some have low understanding. Therefore, it is necessary to investigate students who have a low understanding as well as their self-confidence. Another study on conceptual understanding and self-confidence focused only on the final result using quantitative methods [33-35]. Those previous research emphasize the final results of mathematical, conceptual understanding, and self-confidence after implementing the discovery learning models. Therefore, different from previous studies, this current study aims to delve into a conceptual understanding and self-confidence of four students and analyze them in-depth.

2. Methods
This research used a qualitative approach with a descriptive type. The qualitative approach aims to construct meaning about a phenomenon based on participants’ views [36-37]. The participants in this study were 19 seventh-grade students in one of the junior high schools in Meukek, South Aceh. Initially, the researchers conducted a written pretest to students. The pretest aimed to measure students’ understanding of mathematical concepts that would be categorized into high, moderate, and low ability levels. In this phase, the researchers also administered a self-confidence questionnaire to students to get information about students' self-confidence before participating in the discovery learning. Data obtained from the test and questionnaire were then analyzed. The analysis results would become the basis for selecting the subjects in this study.

After selecting the research subjects, the researchers implemented the discovery learning models in the classroom four times. Then, we conducted the final test (written post-test) consisting of five questions and distributed the questionnaire. It aimed to measure students' understanding of mathematical concepts and self-confidence after treatment. We then analyzed the results of the final
test and self-confidence questionnaire. After obtaining the results, an interview was conducted with the students with low abilities.

The instrument used in this study was a conceptual understanding test designed by the researchers and had been validated by four validators. Meanwhile, the self-confidence questionnaire was adapted and then validated by three validators. The written test consisted of five essay questions, while the questionnaire comprised 26 items—12 positive statements and 14 negative statements. Data of the self-confidence questionnaire were then analyzed based on four indicators of self-confidence. Moreover, the conceptual understanding test was analyzed based on six indicators of conceptual understanding.

3. Result and Discussion
The results of the written tests on students’ conceptual understanding of mathematics and of their self-confidence are presented in Table 1 and Table 2.

| Table 1. Results of conceptual understanding in mathematics. |
|-------------------------------------------------------------|
| Subject          | Before Learning | After Learning |
| SM               | Low            | Moderate       |
| NA               | Low            | Moderate       |
| MN               | Low            | Moderate       |
| WU               | Low            | Low            |

| Table 2. Results of Self-confidence. |
|-------------------------------------|
| Subject | Before Learning | After Learning |
| SM      | Low            | Good           |
| NA      | Good           | Good           |
| MN      | Very Low       | Low            |
| WU      | Low            | Low            |

Based on Table 1 and Table 2, it was found that SM is a subject who initially had a low understanding of mathematical concepts and low self-confidence. After learning with the discovery learning model, SM was classified as having a moderate conceptual understanding and good self-confidence. This finding implies that the discovery learning model had a good impact on students’ understanding of mathematical concepts and self-confidence. Furthermore, NA is a subject who initially had a low understanding of mathematical concepts and good self-confidence. After learning with the discovery learning model, NA had a moderate conceptual understanding and good self-confidence higher than the pre-questionnaire score. Another student, MN, initially possessed a low understanding of mathematical concepts and very low self-confidence. After learning with the discovery learning models, MN reached the category of having a moderate conceptual understanding and low self-confidence. Last, WU is a student who initially had a low understanding of mathematical concepts and low self-confidence. After learning with the discovery learning model, WU stayed in the category where students had a low conceptual understanding and low self-confidence but performed better than before.

Furthermore, students’ answers were analyzed by describing their responses based on indicators of conceptual understanding. An example of student work in written test questions is depicted in Figure 1 and Figure 2.
Figure 1. The student’s answers to the first question.

Figure 2. The student’s answers to the second question.

Figure 1 illustrates the student's response to the question measuring the indicator of providing examples or counter-examples of the concepts. The test results showed that the student correctly answered Question 1, but only four shapes were mentioned. After conducting an in-depth interview, it was found that the student could find six two-dimensional objects–by the addition of rhombus and trapezoidal shapes–and recognized the shapes were not all squares, but some were triangles. This finding implies that, overall, the student met the indicator in question 1, but should have been more careful.

The second question (see figure 2) is a problem that measures the indicator of restating the concepts that have been learned. The results found that the student understood the answers given to this question, although he had little doubt about the properties of a kite’s sides. This finding indicates that the student reached the intended indicator in question 2, restating the concepts that have been studied.

Regarding the results of the self-confidence questionnaire, we firstly discuss the response of the student SM. In the interview, SM admitted that he was not interested in mathematics and other calculation-related lessons. The student enjoyed sports instead. The student’s interest also affects his ability and confidence in mathematics. However, after learning with the discovery learning model, SM had better self-confidence in mathematics. It happened because, in the discovery learning stages, students were required to find the concepts being learned by themselves. As a result, they could understand the concepts more quickly. In the discovery learning model, students also worked in groups, where students could exchange opinions in their group. Besides, they were asked to come in front of the class to present their group work results. Such a learning process would increase students’ courage and confidence.

Moreover, SM did not look nervous and seemed to communicate fluently during the interview. SM looked highly confident about his answers, even though some answers were wrong. SM answered every question very well. Without being anxious, SM immediately answered the questions, but
sometimes he kept silent as he was confused about the answers. Overall, SM performed well and was courageous to give answers. In the interview, the researcher found that SM did not do well in mathematics learning because SM was interested in sports. He also stated that he was not good in the arithmetic lesson. However, after learning with the discovery learning models, SM had a moderate conceptual understanding and good self-confidence, which was certainly good for SM because it had a good impact on his achievements.

The second student is NA. NA was highly active and always wanted to know about anything that made him doubt, but he quickly forgot about a concept that has been learned. At the beginning of learning, NA possessed good self-confidence with a percentage of 77%. His confidence became better after learning with the discovery learning model, with a percentage of 81%. In the learning process, NA always asked a question related to the lesson he had not yet understood and actively participated in his learning group. Not only during the learning process but also after class, NA looked for the teacher to ask questions regarding the topics or lessons he did not comprehend well. This is confirmed from the interview that NA answered all questions calmly and confidently. Without being anxious, NA immediately answered every question very well. In general, NA had extremely good self-confidence. Similarly, based on the questionnaire results, NA was considered to have good self-confidence. The pretest results showed that NA was a student who had a low conceptual understanding and good self-confidence. One of the potential causes was that NA was enthusiastic in learning yet quickly forgot the lessons studied, which became his obstacle in understanding concepts. The interviews and post-test results reported that NA achieved moderate conceptual understanding and good self-confidence after learning with the discovery learning model.

The third student is MN. MN had a basic knowledge of mathematics. Since MN was not interested in mathematics, this student felt less motivated to learn mathematics. MN was more interested in theoretical subjects, such as Indonesian, as revealed during the interview process. MN had low self-confidence because MN was a quiet student in the classroom. However, when he was invited to communicate, MN can communicate well. During the learning process, MN looked silent, not that active. MN answered all the questions when being interviewed, but he was not as enthusiastic as other students. After we interviewed him further and searched for information from the school's mathematics teachers, it was found that MN was indeed a quiet person, but he was good at communication. MN also said that he did not like mathematics; he preferred theoretical subjects to calculation-related subjects. The student’s interest affected his motivation to learn mathematics. From the interview, the researchers saw the potential in MN to be better in mathematics. The challenge was that MN was a quiet person and not too interested in mathematics. However, if the existing potential is well-developed with good motivation and self-confidence, we believe that MN will perform well in mathematics.

The fourth student is WU. WU admitted that he was not interested in calculation-related subjects; he preferred religious subjects. As such, he found it difficult to understand mathematics. This belief affected the student’s understanding of the math lessons, resulting in not optimal learning outcomes. WU’s self-confidence was considered sufficient because WU was willing to ask questions and actively work in a group during the learning process. WU seemed quite active during the learning process, and group works. He asked questions when he did not understand the lesson. WU also appeared supremely confident and fluently gave answers. Nevertheless, sometimes, the answers he gave did not meet the expectation, and most importantly, WU did not hesitate when answered questions in the interview. WU immediately stated he forgot or “do not know” if he did not know or forgot the answers. The researchers considered WU to have good enough self-confidence, but he should learn more for his cognitive ability or the lesson that has been studied.

In general, students’ self-confidence was in a good category. It could be seen from each indicator score. The first indicator scored 63%, which means that this indicator was in a low category. The second indicator had a score of 73%, regarded as the good category. The third indicator was considered in the good category with a score of 74%, and the last indicator obtained a score of 71%.
also in the good category. Of all the indicators measured, only one indicator was in a low category—i.e., the indicator of believing in their own abilities.

Based on the results described above, it is recommended that the discovery learning model be used as an alternative learning model that can be applied in a mathematics classroom. The implementation of the discovery learning model should be conducted in partnership so that the teachers not only focus on low-ability groups of students but also supervise high- and moderate-ability groups of students. Implementing a discovery learning model needs good planning and time management because it takes a long time to follow the learning model stages. The teacher should also understand students’ characters and abilities in the classroom so that the teacher will not make a mistake in classifying students. It is suggested that other researchers conduct a similar study using more innovative methods, approaches, or strategies to obtain optimal results.

4. Conclusion
The current study investigated students’ understanding of mathematical concepts and self-confidence after implementing the discovery learning model. The results showed that the students’ understanding of mathematical concepts and self-confidence performed better after the discovery learning implementation. The students who initially had low ability to understand mathematical concepts had improved their understanding, which was in the moderate category, after learning with the discovery learning model. Out of six indicators of mathematical, conceptual understanding, four indicators were met by students. However, students were still deficient for indicators of presenting concepts in various representations and linking various mathematical concepts internally or externally. Regarding self-confidence, the findings indicated that students reached the indicators of act independently in decision-making, good self-concepts, and dare to express opinions. Nevertheless, students still lacked the indicator of believing in their own abilities.

References
[1] Kementerian Pendidikan dan Kebudayaan 2013 *Kerangka Dasar dan Struktur Kurikulum 2013* (Jakarta: Kementerian Pendidikan dan Kebudayaan)
[2] Darling-Hammond L, Flook L, Cook-Harvey C, Barron B and Osher D 2020 Implications for educational practice of the science of learning and development *Appl. Dev. Sci.* 24 97–140
[3] Riccomini P J, Smith G W, Hughes E M and Fries K M 2015 The language of mathematics: The importance of teaching and learning mathematical vocabulary *J. Read. Writ.* Q. 31 235-52
[4] Tambychik T, Meera T S M and Aziz Z 2010 Mathematics skills difficulties: A mixture of intricacies *Int. Conf. Learn. Divers. Procedia-Social Behav. Sci.* 7 171–80
[5] Murizal A, Yaman and Yerizon 2012 Pemahaman konsep matematis dan model pembelajaran quantum teaching *J. Pendidik. Mat.* 1 19-23
[6] Clark K M 2012 History of mathematics: Illuminating understanding of school mathematics concepts for prospective mathematics teachers *Educ. Stud. Math.* 81 67-84
[7] Sanjaya W 2009 *Strategi Pembelajaran yang Berorientasi Standar Proses Pendidikan* (Jakarta: Kencana Prenada Media Group)
[8] Nuri B and Marsigit 2018 The reluctance of students to ask in mathematics learning: How does the teacher solve it? *J. Phys. Conf. Ser.* 1320 012069
[9] Margono S 2005 *Metodologi Penelitian Pendidikan* (Jakarta: Rineka Cipta)
[10] Stankov L, Morony S and Lee P Y 2013 Confidence: The best non-cognitive predictor of academic achievement? *Educ. Psychol.* 34 9-28
[11] Lauster P 1990 *Tes Kepribadian* (DH Gulo, Trans.) (Jakarta: Bumi Aksara)
[12] Zarkasyi M W 2015 *Penelitian Pendidikan Matematika* (Bandung: Refika Aditama)
[13] Bernard M and Senjayawati E 2019 Developing the students' ability in understanding mathematics and self-confidence with VBA for Excel *J. Res. Adv. Math. Educ.* 4 45-56
[14] Purwashi R 2015 Peningkatan kemampuan pemahaman matematis dan self confidence siswa MTs di kota Cimahi melalui model pembelajaran inkuiri terbimbing Didaktik 9 16-25
[15] Çifçi S K and Yildiz P 2019 The effect of self-confidence on mathematics achievement: The metaanalysis of trends in International Mathematics and Science Study (TIMSS) Int. J. Instr. 12 683-94
[16] Lamibao L S, Luna C A and Namoco R A 2016 The influence of mathematical communication on students’ mathematics performance and anxiety Am. J. Educ. Res. 4 378-82
[17] Dewi I A P A P, Japa I G N and Sumantri M P 2016 Pengaruh masalah realistik terhadap pemahaman konsep matematika bagi siswa kelas V Gugus VII Kecamatan Buleleng Mimbar PGSD Undiksha 4 23-30
[18] Putra H D 2017 Pengembangan instrumen untuk meningkatkan kemampuan mathematical problem posing siswa SMA J.Euclid 4
[19] Yoshida L P, Ibrahim I and Said A 2014 Hubungan self-confidence dengan kecemasan siswa ketika bertanya di dalam kelas Konselor 3 132-8
[20] Khun-Inkeeree H, Omar-Fauzze M and Othman M 2017 The effect of students confidence level toward mathematics performance among Southern Thailand primary school children Int. J. Acad. Res. Progress. Educ. Dev. 6 20-34
[21] Lestari K E and Yudhanegara M R 2015 Penelitian Pendidikan Matematika (Bandung: Refika Aditama)
[22] Surya E, Putri F A and Muktar 2017 Improving mathematical problem-solving ability and self-confidence of high school students through contextual learning model Journal on Mathematics Education 8 85-94
[23] Rizqi H Y, Waluya S B and Wiyanto 2020 Mathematics communication skill viewed from self-confidence in Auditory Intellectually Repetition (AIR) learning model with RME approach Unnes J. Math. Educ. Res. 10 162-7
[24] Hamalik O 2012 Manajemen Pengembangan Kurikulum (Bandung: PT. Remaja Rosdakarya)
[25] Dina Z H, Ikhsan M and Hajdin 2019 The improvement of communication and mathematical disposition abilities through discovery learning model in junior high school J. Res. Adv. Math. Educ. 4 11-22
[26] Chase K and Abrahamson D 2018 Searching for buried treasure: Uncovering discovery in discovery-based learning Instr. Sci. 46 11-33
[27] Martaida T, Bukit N, Ginting E M 2017 The effect of discovery learning model on student's critical thinking and cognitive ability in junior high school IOSR J. Res. Method Educ. (IOSR-JRME) 7 1-8
[28] Putrajaya I M, Syahruddin and Margunayasa I G 2014 Pengaruh model pembelajaran discovery learning dan minat belajar terhadap hasil belajar IPA siswa Mimbar PGSD Undiksha 2
[29] Lubis A B, Miaz Y and Putri I E 2019 Influence of the guided discovery learning model on primary school students’ mathematical problem-solving skills Mimbar Sekolah Dasar 6 253-66
[30] Lestari K E 2016 Penelitian Pendidikan Matematika (Bandung: Refika Aditama)
[31] Syah M 2003 Psikologi Belajar (Jakarta: PT Raja Grafindo Persada)
[32] Park J H, Lee I H and Cooc N 2018 The role of school-level mechanisms: How principal support, professional learning communities, collective responsibility, and group-level teacher expectations affect student achievement Educ. Adm. Q. 55 742-80
[33] Yusmanto and Herman T 2015 Pengaruh penerapan model pembelajaran discovery learning terhadap peningkatan kemampuan berpikir kritis matematis dan self confidence siswa kelas V sekolah dasar EduHumaniora J. Pendidik. Dasar Kampus Cibiru 7 140-51
[34] Travers S T 2017 A Quantitative Analysis of Methods Used for Avoidance and Acceleration of Developmental Mathematics Sequences in Community College (Doctoral Dissertation, Illinois State University)
[35] Stevenson D L, Beckmann S, Johnson S E and Kang R 2018 Quantitative (and non-quantitative) methods used by future teachers for solving probability-based proportion problems Proc. of the 40th Annual Meeting of the north American Chapter of the International Group for the Psychology of Mathematics Education Ed. T E Hodges, G J Roy and A M Tyminski (Greenville, SC: University of South Carolina & Clemson University) pp 687-94
[36] Creswell J W 2013 Research Design: Pendekatan Kualitatif, Kuantitatif, dan Mixed (Yogyakarta: Pustaka Pelajar)
[37] Guillen F and Elida D 2019 Qualitative research: Hermeneutical phenomenological method J. Educ. Psychol. - Propos. y Represent. 7217-29