International Journal of Multicultural and Multireligious Understanding

http://ijmmu.com
editor@ijmmu.com
ISSN 2364-5369
Volume 12, Issue 9
September, 2025
Pages: 136-144

The Effect of Discovery Learning Model Based on Differentiated Instruction on High School Students' Mathematical Conceptual Understanding and Self-Regulated Learning in Trigonometric Ratios Material

Zhurwahayati Putri; Ali Mahmudi

Department of Mathematics and Science, Yogyakarta State University, Indonesia

http://dx.doi.org/10.18415/ijmmu.v12i9.7011

Abstract

This study aims to describe: (1) the effect of discovery learning model based on differentiated instruction on students' mathematical concept understanding and self-regulated learning; (2) the superiority of discovery learning model based on differentiated instruction learning model in terms of students' mathematical concept understanding; and (3) the superiority of discovery learning model based on differentiated instruction in terms of students' self-regulated learning. This research is a quasi-experimental study. The population of this study consisted of all grade X students at State Senior High School 1 Sape during the first semester of the 2024/2025 academic year. The samples included classes X-B and X-D, each comprising 39 students. Class X-D served as the experimental group using discovery learning model based on differentiated instruction (DLDI), while class X-B served as the control group with the direct instruction learning model (DI). Data collection methods included a mathematical concept understanding test consisting of four essay questions and a self-regulated learning questionnaire with 16 statements. To determine the effect of the learning models, a two-sample mean vector comparison test using Hotelling's T^2 statistic was employed. Additionally, to assess the superiority of the DLDI model over the DI model, an independent t-test was used. This analysis also identified the more effective learning model for each specific skill. The study results indicate that: (1) The DLDI learning model significantly influences students' mathematical concept understanding and self-regulated learning simultaneously; (2) The DLDI model outperforms the DI learning model in terms of students' mathematical concept understanding; and (3) The DLDI model outperforms the DI learning model in terms of students' self-regulated learning.

Keywords: *Discovery Learning Model; Differentiated Instruction; Conceptual Understanding Ability; Self-Regulated Learning Ability*

Introduction

Education plays a vital role in shaping a smart, moral, independent, and responsible generation. According to the Ministry of Education's 2022 decree, education is essential for developing a society based on Pancasila and national goals, aiming to produce individuals who are religious, ethical, knowledgeable, and capable. Mathematics is a core subject in Indonesian schools as mandated by the national curriculum. According to Permendikbud No.22 of 2016, mathematics education aims to develop

students' conceptual understanding, reasoning, problem-solving, and communication skills, as well as to foster a positive attitude toward the subject.

Understanding mathematical concepts is essential for learning more complex material. According to Santrock (2018), concept mastery involves identifying, representing, and interpreting mathematical ideas. NCTM indicators emphasize conceptual clarity through various forms, such as models, definitions, and comparisons.

Studies show many students struggle with concept comprehension, especially when learning is time-constrained or focused mainly on rote procedures. This often leads to errors in problem-solving (Hsu et al., 2021; Insani & Kadarisma, 2020). Students with strong concept understanding are more adept at recognizing patterns and solving problems efficiently (Radiusman, 2020).

International assessments like PISA reveal concerning trends. In 2022, Indonesia's performance in mathematics, reading, and science dropped compared to 2018. Only 28% of Indonesian students reached the minimum math proficiency level, far below the OECD average of 76%. Indonesia's average PISA math score of 379 is significantly below the global average of 479. This highlights the need to strengthen students' mathematical understanding. National exam data from 2019 supports this concern, showing that trigonometry and geometry pose particular challenges for students.

Trigonometry is especially difficult for many class X students. Research shows that students often memorize formulas without truly understanding them (Jatisunda, 2019). This lack of comprehension leads to confusion when applying formulas or solving real-world problems. One contributing factor to these difficulties is students' low learning independence. According to Edi (2018), self-regulated learning (SRL) — the ability to plan, monitor, and assess one's learning — is crucial for deep understanding. SRL supports goal-setting, time management, and active engagement. Schunk and Zimmerman (1997) describe SRL as a proactive learning process involving strategy selection, self-monitoring, and reflection. When students manage their learning effectively, they are more likely to succeed academically (Schunk & Ertmer, 2000).

Unfortunately, many Indonesian students still rely heavily on teachers or peers. Studies show that they use ineffective strategies like rote memorization and struggle with managing their study time (DiFrancesca et al., 2016). This dependence hinders the development of SRL. To address diverse student needs, educators are encouraged to adopt differentiated learning — an approach that adapts instruction to students' readiness, interests, and learning styles. This method promotes engagement and deeper understanding (Tomlinson, 2013; Marlina, 2020).

When combined with structured methods like discovery learning, differentiated instruction can significantly improve learning outcomes. This research investigates the impact of using a discovery learning model based on differentiated learning to enhance students' conceptual understanding and self-regulated learning in trigonometric comparison topics in class X.

Method

This research includes pseudo-experimental research because researchers cannot fully control or manipulate all relevant variables, except for some of the variables studied. In addition, pseudo-experiments use classes that already exist, and not all other variables involved in the experiment can be strictly controlled. Furthermore, this study aims to determine the effect of *discovery learning* model based on differentiated learning on students' concept understanding ability and *self-regulated learning* (SLR). In this study, two groups of experimental classes were treated based on the *discovery* learning model based on differentiated learning (DLDI) and control classes were treated based on classical learning with *direct instruction* (DI) model. The place of this research was State Senior High School 1 Sape, with the research

subjects being class X students in the odd semester of the 2024/2025 academic year which was held from August 13, 2024 to September 26, 2024 for 6 meetings.

In this study, data were collected through a combination of test and non-test methods. Test data were obtained from the assessment scores of students' concept understanding and *self-regulated learning* skills, which included the results of the pretest and posttest. Meanwhile, non-test data was collected through *self-regulated learning* questionnaire. This study used descriptive and inferential analysis techniques. Descriptive analysis aims to describe learning outcomes based on data collected before (*pretest*) and after treatment (*posttest*) on each observed dependent variable. The data presented includes the mean, standard deviation, and maximum and minimum values. This analysis is done by comparing the average score of each variable with the predetermined minimum completeness criteria. In addition, the learning implementation observation sheet was used to measure the percentage of learning process implementation at each meeting. Meanwhile, inferential analysis is used to process research sample data that represents a certain population. This analysis also serves to statistically test the research hypothesis and answer the research questions that have been formulated. In the analysis process, researchers used *RStudio software* to process the data obtained.

Results and discussion

Result

1. Description of Research Data

This study was conducted with the aim to determine the effect of *Discovery Learning* model based on Differentiated Learning (DLDI) on the ability to understand mathematical concepts and students' *self-regulated learning*. This research was conducted at SMA Negeri 1 Sape in the odd semester of the 2024/2025 academic year. The material presented is related to trigonometric comparison. This research was conducted from August 13 to September 26, 2024. The results of observations related to the implementation of learning can be seen in Table 1 below.

Table 1. Observation Results of Learning Model Implementation

Meeting	DLDI class		DI class	
	Teacher Activities	Student Activities	Teacher Activities	Student Activities
1st meeting	*Pretest*	*Pretest*	*Pretest*	*Pretest*
2nd meeting	82%	82%	83%	77%
3rd meeting	91%	84%	90%	83%
4th meeting	95%	95%	95%	95%
5th meeting	100%	100%	100%	100%
6th meeting	*Posttest*	*Posttest*	*Posttest*	*Posttest*

Based on the data presented in Table 1, the highest percentage of learning implementation in both classes occurred at the fifth meeting, with the percentage reaching 100%. In the first and last meetings, activities focused on working on the *pretest* and *posttest*. The second meeting in the experimental class, the researcher divided students according to their *learning profile* into group or individual discussions so that it consumed enough time. In addition, the researcher also did not have time to direct students to make conclusions due to time constraints. In the control class, the researcher experienced problems in managing the class, so did not have time to check the students' attendance or direct them to prepare learning equipment. The limited time also made researchers unable to convey the material that would be discussed at the next meeting.

In the third meeting in the experimental class, the researcher did not have time to provide an overview of the topics discussed and direct students to summarize important points. Meanwhile, in the control class, insufficient time caused the researcher to again not be able to convey the material for the next meeting.

2. Concept Understanding Ability Test Data

This study measured students' mathematical concept understanding using a description test consisting of 4 questions. The test instrument was applied to both classes, both experimental and control, and was used in the *pretest* and *posttest*. The score for this test is in the range of 0 to 100. The results of descriptive statistics regarding concept understanding data are shown in Table 2 below.

Table 2. Descriptive Statistics of Concept Understanding Ability Data

Description	DLDI class		DI Class	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Ideal maximum score	100	100	100	100
Maximum Value	59.38	96.88	53.13	90.60
Ideal Minimum Value	0	0	0	0
Minimum Value	34.38	59.40	34.38	40.63
Average	45.83	79.57	43.91	67.47
Variance	37.23	109.54	20.48	173.08
Standard Deviation	6.10	10.60	4.53	13.16

Based on the results in Table 2, the average concept understanding score in the DLDI class (experimental) increased from 45.83 to 79.57, while in the DI class (control) it increased from 43.91 to 67.47. The comparison between the average concept understanding of the two classes shows that the average value in the DLDI class is higher than the DI class.

3. *Self-Regulated Learning* Ability Test Data

In this study, students' SRL ability was measured through *pretest* and *posttest* data from the SRL questionnaire in both classes. Table 3 below provides a statistical summary of students' SRL ability data for the experimental and control classes.

Table 3. Data Statistics of SRL Ability in Both Classes

Description	DLDI class		DI Class	
	Pretest	*Posttest*	*Pretest*	*Posttest*
Learning goal setting	4.410 (55.1%)	5.692 (71.2%)	4.410 (55.1%)	4.487 (56.1%)
Determination of learning strategy	15.103 (53.9%)	19.923 (71.2%)	15.051 (53.8%)	17.949 (64.1%)
Monitoring learning objectives and processes	7.051 (58.8%)	8.564 (71.4%)	7.128 (59.4%)	7.974 (66.5%)
Evaluating learning objectives and processes	9.462 (59.1%)	9.615 (60.1%)	8.128 (50.8%)	8.897 (55.6%)
Ideal maximum value	64	64	*64*	*64*
Maximum Value	45	50	45	47
Ideal Minimum Score	16	16	16	16
Minimum Value	24	37	25	29
Average	36.026	43.795	35.487	38.538
Variance	22.487	10.317	24.455	17.838
Standard Deviation	4.742	3.212	4.945	4.224

Table 3 shows that both learning methods successfully improved students' *self-regulated learning* (SRL). This can be seen from the average increase in each aspect and overall SRL. In the experimental class (DLDI), the average increased from 36.026 to 43.795, while in the control class (DI), the average increased from 35.487 to 38.538. The data in the table also indicates that the SRL of students learning with DLDI is better than that of students learning using DI. This is evidenced by the final average of students' SRL in the experimental class which is higher than the control class after the treatment is given.

The improvement of SRL can also be seen from the average of each aspect, namely setting learning goals, determining learning strategies, monitoring learning goals and processes, and evaluating learning goals and processes. The indicator of determining learning strategies showed the greatest improvement in both classes. In the experimental class, the average indicator of determining learning strategies increased by 17.3%, while in the control class it increased by 10.3%. The indicator of determining learning strategies seems to be the easiest aspect of SRL to develop in learning trigonometry, both with DLDI and DI learning. In contrast, the indicator of evaluating learning goals and processes showed the smallest increase in both classes. In the experimental class, the average indicator of evaluating learning goals and processes only increased by 0.9%, while in the control class it increased by only 4.9%.

The control class experienced an increase of only 4.8%. This shows that the indicator of evaluating learning goals and processes is more difficult to improve than other aspects of SRL.

Discussion

a. Comparison Test of Two Mean Vectors

The mean vector comparison test aims to evaluate the effect of DLDI learning model on both abilities simultaneously. Based on the results of multivariate normality test and homogeneity of population variance-covariance matrix, the test statistic $Hotelling's\ T^2$ with significance level $\alpha = 0.05$ was used. The results of this test are shown in Table 4 below.

Table 4. Results of Comparison of Two Mean Vectors

Treatment	Comparison Test of Two Vector Averages	
	$Hotelling's\ T^2$	$p-value$
Before Treatment	2.875	0.238
After Treatment	63.921	$1.321x10^{-14}$

The results in Table 4 show that before treatment, $p-value = 0.238 > 0.05$, which indicates that the learning model has no effect on the ability of concept understanding and *self-regulated learning* before treatment. Therefore, the two classes, both experimental and control, have equal abilities. After the treatment, $p-value = 1.321x10^{-14} < 0.05$, which indicates that there is an effect of the learning model on the ability to understand concepts and *self-regulated learning* after treatment. Since the simultaneous test result is significant, the partial test can be continued.

b. Univariate Test t

Univariate *t* test is used to identify the effect of superior learning model on each variable partially. The test statistic used is $Independent\ Sample\ t-Test$ with a significance level of $\alpha = 0.05$. The results of the t test analysis are presented in Table 5 below.

Table 5.t Test Results

Variable	Two Independent Samples Test t	
	Test t	$p-value$
Conceptual Understanding	4.438	0.0000152
Self-Regulated Learning	6.107	0.00000002

Based on the results shown in Table 5, it is known that for concept understanding ability, it is obtained $p-value = 0.0000152 < 0.05$. This shows that the DLDI learning model is superior to the DI model on concept understanding ability. For *self-regulated learning*, obtained$p-value = 0.00000002 < 0.05$, which shows that the DLDI *learning* model is also superior to the DI model on the ability of *self-regulated learning.*

Conclusion

Based on the results of hypothesis testing and discussion described in the previous chapter, the following conclusions are obtained:

1. The results of the comparison test of two average vectors of posttest data on students' concept understanding ability and *self-regulated learning* show the value of $Hotteling's\ T^2 = 63.921$ with $p-value = 1.321x10^{-14}$ This indicates that the DLDI and DI learning models simultaneously have an influence on students' concept understanding ability and *self-regulated learning*.

2. Based on the *posttest* data of concept understanding ability with *independent sample t-test* test, it is found that DLDI learning model gives superior effect than DI learning model in terms of concept understanding ability.

3. Based on the *posttest* data of *self-regulated learning* ability with *independent sample t-test* test, it is found that DLDI learning model gives superior effect compared to DI learning model in terms of *self-regulated learning* ability.

References

Aprima, D., & Sari, S. (2022). Analisis penerapan pembelajaran berdiferensiasi dalam implementasi kurikulum merdeka pada pelajaran matematika SD.

Aunurrahman. (2009). Belajar dan Pembelajaran. Bandung: Alfabeta.

Anggraini, K., Octaria, D., & Sumarno,E (2023). Implementasi Pendekatan Pembelajaran Berdiferensiasi Model Pembelajaran Problem Based LearningUntuk Meningkatkan Kemandirian Belajar Siswa Kelas X SMAN 2 Palembang. Jurnal Sinar Edukasi(JSE) Vol. 04, 31-48.

Arsyad, M. (2021). Teori Belajar dan Peran Guru pada Pendidikan di Era Revolusi Industri 4.0. Raja Grafindo Persada.

Basir, N. E. S., Jusniar, & Razak, A. (2023). Penerapan Pembelajaran Berdiferensiasi dengan Model Discovery Learning untuk Meningkatkan Hasil Belajar Peserta Didik. Jurnal Pemikiran Dan Pengembangan Pembelajaran, 5(3), 896–904.

Bruner, J. S. (1961). The Act of Discovery. In In Search of Pedagogy Volume I. USA: Harvard Educational Review. https://doi.org/10.4324/9780203088609- 13.

Damayanti, Firsa dan Intan Sari Rufiana. (2020). Analisis Pemahaman Konsep Matematika pada Materi Bangun Ruang Kubus dari Balok di Tinjau dari Motivasi Belajar. Jurnal Edupedia. Ponorogo: Universitas Muhammadiyah Ponorogo, 4(2), 72-180.

Diana, P., Marethi, I., & Pamungkas, A. S. (2020). Kemampuan Pemahaman Konsep Matematis Siswa: Ditinjau dari Kategori Kecemasan Matematik. SJME (Supremum J Math Educ) 4(1), 24-32. https://doi.org/10.35706/sjme.v4i1.2033.

DiFrancesca, D., Nietfeld, J. L., & Cao, L. (2016). A comparison of high and low achieving students on self-regulated learning variables. Learning and Individual Differences, 45, 228–236. https://doi.org/10.1016/j.lindif.2015.11.010.

Edi, E. (2018). Pengaruh Konsep Diri Dan Kemandirian Belajar Terhadap Penguasaan Konsep Matematika. Jurnal Pendidikan MIPA, /(3), 251-258.

El-Adl, A., & Alkharusi, H. (2020). Relationships between self-regulated learning strategies, learning motivation and mathematics achievement. *Cypriot Journal of Educational Sciences, 15*(1), 104–111. https://doi.org/10.18844/cjes.v15i1.4461.

Fox, Jenifer & Hoffman, Whitney.. 2011. The differentiated instruction: Book of lists. CA:

Hsu, Y. C., Ching, Y. H., Callahan, J., & Bullock, D. (2021). Enhancing STEM Majors' College Trigonometry Learning through Collaborative Mobile Apps Coding. TechTrends, 65(1). https://doi.org/10.1007/s11528-020-00541-0.

Insani, M. I., & Kadarisma, G. (2020). Analisis Epistemological Obstacle Siswa SMA pada Materi Trigonometri. JPMI - Jurnal Pembelajaran Matematika Inovatif, 3(5).

Jatisunda, M. G. (2019). Kesulitan Siswa Dalam Memahami Konsep Trigonometri Di Lihat Dari Learning Obstacles. *Didactical Mathematics*, *2*(1), 9. https://doi.org/10.31949/dmj.v2i1.1664.

Jingga, Anisa Astra, Mardiyana, and Rubono Setiawan. 2017. "Analisis Kesalahan Siswa Dalam Menyelesaikan Soal Identitas Trigonometri Pada Siswa Kelas X Semester 2 SMA Negeri 1 KartasuraTahun Ajaran 2015/2016." Jurnal Pendidikan Matematika Dan Matematika (JPMM) 1(5):48–62. doi: 10.4135/9781849209403.n73.

Joyce, B., Weill, M., & Calhoun, E. (2004). Models of teaching (7thed). Boston: Allyn & Bacon.

Kamber, D., & Takaci, D. (2018). On problematic aspects in learning trigonometry. International Journal of Mathematical Education in Science and Technology, 49(2). https://doi.org/10.1080/0020739X.2017.1357846.

Kartikasari, I. A., Usodo, B., & Riyadi. (2022). The effectiveness open-ended learning and creative problem-solving models to improve creative thinking skills. Pegem Journal of Education and Instruction, 12(4), 29-38. http://doi.org//10.47750/pegegog.12.04.04.

Keputusan Mendikbudristek RI No. 262/M/2022 tentang Perubahan atas Keputusan Mendikbudistek RI No. 56/M/2022 tentang Pedoman Penerapan Kurikulum dalam Rangka Pemulihan Pembelajaran.

Kurniyawati, Y., Mahmudi, A., & Wahyuningrum, E. (2019). Efektivitas problembased learning ditinjau dari keterampilan pemecahan masalah dan kemandirian belajar matematis. Jurnal Riset Pendidikan Matematika, 6(1), 118-129. doi: https://doi.org/10.21831/jrpm.v6i1.26985.

Magee, Monique & Elizabeth Breaux. (2010). How The Best Teachers Differentiate Intruction. New York: Routledge.

Marlina, M. (2020). Strategi Pembelajaran Berdiferensiasi di Sekolah Inklusif. Padang: Afifa Utama.

Menteri Pendidikan, K. R. (2022). Peraturan Menteri Pendidikan, Kebudayaan, Riset, Dan Teknologi Republik Indonesia Nomor 5 Tahun 2022 Tentang Standar Kompetensi Lulusan pada Anak Usia Dini, Jenjang Pendidikan Dasar, dan Jenjang Pendidikan Menengah. Indonesia.

Merchant,S. (2010).Methods of Teaching Mathematics. Hambard University, Karachi. HIESS.1-13. Retrieved on 10th December 2010 from http://www.scribd.com/doc/8528335/methods-of-teaching-mathematics.

Miscevic-Kadijevic, G. (2015). TIMMS 2011: Relationship between selfconfidence and cognitive achievement for Serbia and Slovenia. Revista Electrónica de Investigación Educativa, 17(3), 109-115. Retrieved from http://redie.uabc.mx/vol17no3/contents-miscevic.html.

OECD. (2018). Programme for internasional student assesment (PISA) resulat from PISA 2018. 1-10.

OECD. (2023). PISA 2022 Results Factsheets Indonesia. In OECD (Vol. 1).

Peraturan Menteri Pendidikan dan Kebudayaan Nomor 22 tahun 2016 tentang standar proses pendidikan dasar dan menengah, (2016).

Radiusman, R. (2020). Studi literasi: Pemahaman konsep siswa pada pembelajaran matematika. FIBONACCI: Jurnal Pendidikan Matematika dan Matematika, 6(1), 1-8.

Saleh Haji. (2019). NCTM's Principles and Standards for Developing Conceptual Understanding in Mathematics. Journal of Research in Mathematics Trends and Technology, 1(2), 56–65. https://doi.org/10.32734/jormtt.v1i2.2836.

Santrock, J. W. (2018). Educational psychology. In D. Groundwater (Ed.), McGraw-Hill (5 ed.). Micheal Sugarman.

Schunk, D. H. & Ertmer, P. A. (2000). *Self-regulation and academic learning: self-efficacy enhancing interventions. In M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds.), Handbook of self-regulation. Cambridge, MA: Academic Press.*

Schunk, D. H. & Zimmerman, B. J. (1997). *Social origins of self-regulatory competence. Educational Psychologist, 32, 195–208. doi:10.1207/s15326985ep3204_1*.

Septian, A., & Komala, E. (2019). Kemampuan Koneksi Matematik dan Motivasi Belajar Siswa Dengan Mengunakan Model Problem-Based Learning (PBL). Jurnal PRISMA Universitas Suryakancana, VIII(1), 1–13. https://jurnal.unsur.ac.id/prisma.

Sidik NH., M. I., & Winata, H. (2016). MENINGKATKAN HASIL BELAJAR SISWA MELALUI PENERAPAN MODEL PEMBELAJARAN DIRECT INSTRUCTION. *Jurnal Pendidikan Manajemen Perkantoran*, *1*(1), 49. https://doi.org/10.17509/jpm.v1i1.3262.

Susana, K., Muhtarom, & Subandijah, S. (2023). 286. Implementasi Pembelajaran Berdiferensiasi untuk Meningkatkan Kemampuan Pemahaman Matematis Siswa SMK. *Prosiding Seminar Nasional Pendidikan Profesi Guru*, (2022), 2548–2554.

Susanti, U., & Wutsqa, D. (2020). Keefektifan pendekatan contextual teaching learning dan problem solving ditinjau dari prestasi dan kepercayaan diri siswa. Jurnal Riset Pendidikan Matematika, 7(1), 97-107. doi: https://doi.org/10.21831/jrpm.v7i1.8537.

Tesi, L., Lambertus, & Mukhsar. (2018). Pengaruh Pendekatan Open Ended dan Pendekatan Realistic Mathematics Education Terhadap Kemampuan Pemecahan Masalah Matematik Ditinjau dari Motivasi Belajar Siswa. Jurnal Pendidikan Matematika, 9(1), 102-113.

Tomlinson, C. A., & Moon, T. R. (2013). Assessment and Student Success in a Differentiated Classroom. Alexandria, VA: Association for Supervision and Curriculum Development.

Westwood, Peter. 2008. What Teachers Need to Know about Teaching Methods. Victoria: ACER Press Zimmerman, Bonner, & Kovach. (1996). Developing self-regulated learners.

Copyrights