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Influence of the Instagram-Assisted Flipped Classroom Learning Model on Students' Mathematical Communication at Middle School

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ABSTRACT

It is important for schools to improve students' mathematical communication. However, a preliminary study at Public Middle School 1 Bulango Selatan revealed that some students still struggle to solve problems given by the teacher, particularly those related to determining the length of a side of a flat shape, especially in the context of congruence and similarity. Therefore, the intent of this study was to determine the effect of the flipped classroom learning model assisted by Instagram on students' mathematical communication at Public Middle School 1 Bulango Selatan. The method used in this study was an experimental method consisting of an experimental class and a control class with a research design used, namely a post-test-only group design. We conducted a t-test data analysis on both the experimental and control classes. The findings of the study showed that the t-count was greater than the t-table value; specifically, the t-count was 2.083, which is greater than 2.042, leading to the rejection of H0. Thereby, it can be concluded that learning using the flipped classroom learning model on the material of congruence and similarity of flat shapes can affect students' mathematical communication skills.

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1. INTRODUCTION

Mathematics in Greek means knowledge, thought, study, and learning. Mathematics is a science that studies patterns, structures, spaces, and quantitative relationships between various objects and natural phenomena (Serra, 2023). In general, mathematics is defined as a science that uses reason to analyze objects carefully, explain accurately through symbols and concepts, and apply rules in operations and modeling (Simon, 2017; Godino et al., 2022).

Mathematics learning in schools is a formal education, in which there is interaction between two or more individuals who have different knowledge (Popovic & Lederman, 2015). In the learning process, students are expected to be able to communicate ideas about mathematics to others through verbal language, writing, symbols, tables, diagrams, or other media to explain conditions or problems and can appreciate the

usefulness of mathematics in life in the form of curiosity and interest in learning mathematics (Morgan, 2016; Teledahl, 2017).

Students must possess these essential mathematical skills. The National Council of Teachers of Mathematics states that mathematical communication is a very important basic ability in the field of mathematics and mathematics education (Kosko & Gao, 2017; Aminah et al., 2018; Ata Baran & Kabael, 2021). Mathematical communication skills are put forward by Rombreg and Chair in (Rasyid, 2019; Rahmawati et al., 2022), namely the relationship between real objects, in the form of images and diagrams into mathematical ideas; explaining mathematical ideas, situations, and relations either orally or in writing with real objects, images, graphs and algebra expressed in everyday events in mathematical language or symbols; listening, discussing and writing about mathematics; reading with understanding a written mathematical representation; making conjectures, constructing arguments, formulating definitions and generalizations accompanied by explanations and making statements about the mathematics that has been studied. This statement is in line with the mathematical indicators proposed by Sumarno in Aminah et al. (2018), namely: 1) the connection between real objects, images, and diagrams in mathematical ideas; 2) explanation of mathematical ideas and relations orally and in writing between real objects, images, graphs, and algebra; 3) everyday objects expressed in mathematical language and symbols; 4) listening, discussing, and writing about mathematics; 5) reading written mathematical understanding; 6) making conjectures and arguments that are arranged and formulating definitions and generalizations; and 7) explanation of mathematics that has been studied.

Formal education in schools can play a role in improving students' mathematical communication (Ruswanto et al., 2018; Nuraida & Amam, 2019; Nufus & Mursalin, 2020). However, currently, mathematical communication skills are still low. The low mathematical communication skills of students are caused by several factors, both those related to individual students, the learning environment, and the teaching methods used by teachers (Widjajanti, 2013; Tong et al., 2021). If this decline is allowed to continue, students will experience difficulties in learning mathematics, especially in students' mathematical communication.

Mathematical communication skills can be interpreted as the ability to express mathematical ideas and convey information in the form of symbols, diagrams, and data to others, which is done verbally or in writing (Rahman et al., 2012; Rahmi et al., 2017; Rohid & Rusmawati, 2019). Communication helps students connect their ideas with abstract language using mathematical symbols (Ata Baran & Kabael, 2023; Tinungki et al., 2024; Bal Sarıaltın & Ata Baran, 2025). Students often ask questions related to lessons they dislike, leading some of them to respond with mathematical answers. Students consider mathematics to be one of the difficult subjects because of its abstract nature compared to other subjects (Diego-Mantecon et al., 2021). Therefore, many students do not like mathematics, which does not arouse their love for it.

In addition to the above issues, the learning process is changing because math learning has focused on algorithmic computation (Kallia et al., 2021). Therefore, during

the mathematics learning process, it shows that students can do mathematical calculations but do not show results related to the application of mathematics in everyday life. Learning mathematics is not only about mastering concepts but also about their application in everyday life (Vos, 2018).

Several factors contribute to the lack of mathematical communication skills among students, including their frequent experience of low or passive competitiveness, which leads them to rely more on the teacher's guidance than to seek answers independently (Yaniawati et al., 2019; Ristiana et al., 2025). Teachers are not creative during the delivery of material, using more lecture methods, questions and answers, and giving assignments and exercises during the learning process, resulting in students' lack of critical thinking (Khalid et al., 2021).

Observations at Public Middle School 1 Bulango Selatan reveal that some students still cannot solve the problems given by the teacher, particularly regarding the material on congruence and similarity of plane shapes. For example, students cannot determine the length of the side of a plane shape if the length of the other side of a plane shape is known.

To address the issues mentioned, the author proposes an alternative by implementing a student-centered flipped classroom learning model, in which students first study the assigned material at home before coming to class (Sein-Echaluce et al., 2024). In class, students can work on assignments in groups and have many opportunities to express their opinions, which can improve their communication skills (Akçayır & Akçayır, 2018).

The steps for flipped classroom learning, according to Fauzan et al. (2021) and Reidsema et al. (2017), include: (1) Before face-to-face learning, students are asked to study independently at their respective homes regarding the material for the next meeting by watching learning videos by the teacher himself or learning videos uploaded by other people. (2) In classroom learning, students are divided into several groups. (3) The role of the teacher during the learning activity is to facilitate discussion. Additionally, the teacher prepares several questions or problems based on the material. (4) The teacher gives quizzes or tests so that students are aware that the activities they do are not just games but are a learning process, and the teacher acts as a facilitator in helping students with learning and solving problems related to the material.

The flipped classroom-based learning model is one of the learning models where students are the main center for increasing the effectiveness of learning carried out by students (Chen et al., 2018). Additionally, the flipped classroom learning model is one of the methods used by an educator to reduce direct guidance in the learning process, and this method requires educators to communicate more with students (Njie-Carr et al., 2017). This work is done to further optimize the benefits of the technology used as a learning model so that students can receive material online (Shyr & Chen, 2018; Cabı, 2018). Based on this information, the intent of this study was to determine the effect of the flipped classroom learning model assisted by Instagram on students' mathematical communication.

2. METHOD

This type of research is experimental, and its purpose is to determine the effect of the flipped classroom learning model assisted by Instagram on students' mathematical communication. We conducted this research at Public Middle School 1 Bulango Selatan during the odd semester of 2024/2025. We used two groups, the experimental class and the control class, as research objects in this study. The experimental class used the flipped classroom learning model, while the control class used the conventional learning model. The following presents the post-test-only group design used in this study in Figure 1.

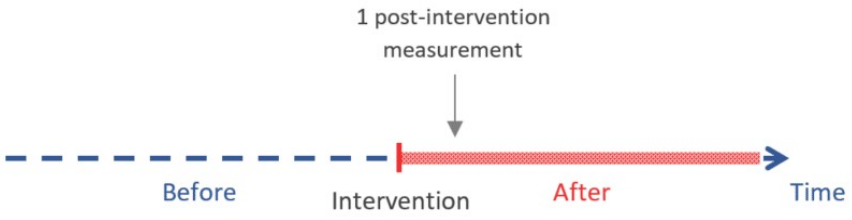

Figure 1. The Post-Test-Only Group Design

The research design used in this study is the post-test-only group design, based on the comparison of the final tests in the two classes. Before the test is given to students, its feasibility is first tested by conducting a test validity test with the test criteria r count ≥ r table; then the test questions can be said to be valid and suitable for use. Next, we conduct a reliability test to determine the suitability of the test instrument. Following the validity and reliability tests, we will conduct a T-test. We conduct a normality and homogeneity test prior to the t-test. The data normality test checks if the data follows a normal distribution using the chi-square test formula, where we reject H_0 if x^2 count is less than x^2 $(1-\alpha)$ and $(n-1)$, and we accept H_0 if x^2 is a different value. The homogeneity test is performed to determine whether the two datasets have the same variance, using the Hartley test formula with the criterion that F-count must be less than F-table. The final step involves conducting a T-test to compare the mathematical communication skills of students in the experimental class with those in the control class.

3. RESULTS AND DISCUSSION

Results

This research is an experimental study that aims to identify the causal relationship and the influence that arises after the application of treatment in the experimental class using the flipped classroom learning model. Meanwhile, the control class did not receive treatment and continued to use the learning model applied in the school. In this study, the researcher took samples from class IX-1 as the experimental class and IX-2 as the control class.

Before implementing the data collection technique, a validity and reliability test was first carried out on the test. The validity test aims to ensure that each question item is

valid and suitable for use in the final test of students' mathematical communication skills. The following are the results of the test validity test in Table 1.

Table 1. Test Validity Test

No	Validation Coefficient		Information
	R Count	R table	
1	0,68	0,4438	Valid
2	0,5849	0,4438	Valid
3	0,6788	0,4438	Valid
4	0,5389	0,4438	Valid
5	0,7652	0,4438	Valid
6	0,5613	0,4438	Valid
7	0,5888	0,4438	Valid

In Table 1, it is known that the test items are valid, so they can be used. After the test validity test is carried out, the next step is to conduct a reliability test to determine whether the test can be used in collecting data on students' mathematical communication skills. The following are the results of the test reliability test in Table 2.

Table 2. Reliability Test of the Test

Reference Value	Testing Criteria	Conclussion
	Cronbach Alpha Value	
0,4438	0,7430	Reliabel

Normal testing is needed to determine whether the student test data is normally distributed or not. The test hypothesis is the test criteria are to accept H_0 if the X^2 t-count $\leq$ the X^2 t-table and reject H_0 if the X^2 t-count > the X^2 t-table at the selected real level α, which is $\alpha = 0.05$. By accepting H_0, it means that the data sample comes from a normally distributed population. The following are the results of the data normality test in Table 3.

Table 3. Data Normality Test

Group	N	X^2 Count	X^2 Table	Conclussion
Experimental Class	19	1,6764	28.869	Normal
Control Class	19	1,3667	28.869	Normal

After ensuring that both samples are normally distributed, the next step is to conduct a homogeneity test on the variables. The homogeneity test of variance is carried out using the F test to determine whether both data have the same variance. This homogeneity test is carried out using the Hartley test at a significance level of $\alpha = 0.05$. It can be said to have the same or homogeneous variance if the calculation results show that the F count is < F table. The results of the homogeneity analysis of experimental and control data are in Table 4.

Table 4. Homogeneity Test

Group	N	DK	F-Count	F-Table	Conclussion
Experimental Class	19	18	1,1383	3,5200	Homogen
Control Class	19	18			

In hypothesis testing, researchers used a two-sample independent t-test to determine the effect of students' flipped classroom learning on mathematics lessons. Furthermore, the results of the test are used to make decisions about whether the research hypothesis can be accepted or rejected. The following are the results of the two-sample independent t-test in Table 5.

Table 5. Hypothesis Testing Results

Group	Mean	SD	Varians	DK	t *Count*	t *table*
Experimental Class	48,105	3,526	14,006	18	2,083	2,042
Control Class	46,684	3,742	12,433	18		

Based on the results of the research that has been conducted, the mathematical communication skills of students who are taught using the flipped classroom learning model are higher than the mathematical communication skills of students who are taught using the conventional learning model. This can be seen in the hypothesis testing with a significant traf $\alpha = 0.05$ and t-count = 2.083 > t-table = 2.042, which results in rejecting H0.

The results of post-test data processing show that the average value of mathematical communication skills of students in the experimental class (class IX-1) using the flipped classroom model is higher than the control class (class IX-2) using the conventional model, which are 48.105 and 46.684. This shows that learning with the flipped classroom model is more effective in improving students' mathematical communication skills compared to conventional learning models.

Discussion

The objective of this study was to assess the impact of the flipped classroom learning paradigm, facilitated via Instagram, on students' mathematical communication at Public Middle School 1 Bulango Selatan. The study's findings indicated that the t-count exceeded the t-table value; precisely, the t-count was 2.083, beyond 2.042, resulting in the rejection of H_0. The analysis of the post-test data shows that the average math communication skills of students in the experimental class (class IX-1), using the flipped classroom model, are higher than those in the control class (class IX-2), which uses the traditional model, with scores of 48.105 and 46.684, respectively. This evidence indicates that the flipped classroom model is more effective than traditional learning models in enhancing students' mathematics communication skills. Consequently, it can be inferred that the implementation of the flipped classroom paradigm in teaching congruence and similarity in planar figures influences students' mathematical communication abilities. The findings of this study align with those of several

investigations, including a study by Ardika et al. (2021) and Mukhayat et al. (2024), which demonstrated that the flipped classroom format greatly impacted students' mathematical communication skills.

The flipped classroom paradigm is a productive and student-centered learning approach (Mingorance Estrada et al., 2019). Flipped classrooms employ technology that facilitates access to educational resources at any time and from any location. The implementation of flipped classrooms enhances the efficacy and efficiency of learning by allowing for flexible study time both at home and in the classroom (Loizou & Lee, 2020). Educators and learners can optimize current education by utilizing accessible media, such as instructional videos.

The flipped classroom style helps enhance students' mathematics communication abilities (Anggo & Samparadja, 2022). This strategy entails students autonomously acquiring new content at home, typically via videos or online resources, while class time is dedicated to discussion, cooperation, and the application of concepts, including practice problems and problem-solving activities (Awidi & Paynter, 2019; Cevikbas & Kaiser, 2020).

The flipped classroom model integrates home and classroom learning, with teachers acting as facilitators, to enable students to comprehend the material more profoundly (Wang et al., 2019). This approach utilizes engaging learning media to enhance the educational experience, aiding students in grasping concepts through auditory and visual stimuli.

The flipped classroom concept can be implemented by leveraging contemporary technology, such as the Instagram application (Andujar & Çakmak, 2020; Fernández-Martín et al., 2020). Instagram offers several functionalities for mathematics education, including photo and video postings for concept elucidation, story features for brief quizzes or sample inquiries, live features for interactive question-and-answer sessions, and reels for concise, engaging instructional movies (Engelbrecht et al., 2020; Richter et al., 2022).

4. CONCLUSION

The results of the study conducted at Public Middle School 1 Bulango Selatan showed that the use of the flipped classroom learning model on the material of congruence and similarity of plane figures has a positive effect on students' mathematical communication skills. Students who learn with the flipped classroom model have better mathematical communication skills compared to students who use conventional learning models. This benefit can be seen in the average scores of the mathematical communication ability test in the experimental and control classes. The advantage is shown based on the calculated t value of 2.083, which is higher than the t-table value of 2.042 at a significance level of 0.05, showing that the difference is important and that the flipped classroom model is more effective in improving students' mathematical communication skills.

The flipped classroom learning model can improve students' mathematical communication skills. Therefore, teachers are advised to apply this learning model,

especially to the material of congruence and similarity, so that the learning process can be carried out optimally both in and outside the classroom. Schools are expected to provide motivation and support to students, especially supporting and not limiting students from using social media in the learning process because this learning model requires social media in the learning process. We expect it to serve as a reference or guideline for other researchers as they complete their final assignments.

REFERENCES

Akçayır, G., & Akçayır, M. (2018). The flipped classroom: A review of its advantages and challenges. *Computers & Education*, *126*, 334-345. https://doi.org/10.1016/j.compedu.2018.07.021

Aminah, S., Wijaya, T. T., & Yuspriyati, D. (2018). Analisis kemampuan komunikasi matematis siswa kelas viii pada materi himpunan. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *2*(1), 15-22.

Andujar, A., & Çakmak, F. (2020). Foreign language learning through instagram: a flipped learning approach. In *New technological applications for foreign and second language learning and teaching* (pp. 135-156). IGI Global. https://doi.org/10.4018/978-1-7998-2591-3.ch007

Anggo, M., & Samparadja, H. (2022). Profil Kemampuan Komunikasi Matematis Mahasiswa Dalam Pembelajaran Desain Blended Learning Tipe Flipped Classroom. *Jurnal Pendidikan Matematika*, *13*(2), 228-241. https://doi.org/10.36709/jpm.v13i2.7

Ardila, A., Marzal, J., & Siburian, J. (2021). The Pengembangan Perangkat Pembelajaran Trigonometri Model Flipped Classroom untuk Meningkatkan Kemampuan Komunikasi Matematis Siswa. *Edumatica: Jurnal Pendidikan Matematika*, *11*(3), 65-77. https://doi.org/10.22437/edumatica.v11i03.14497

Ata Baran, A., & Kabael, T. (2021). An investigation of eighth grade students' mathematical communication competency and affective characteristics. *The Journal of Educational Research*, *114*(4), 367–380. https://doi.org/10.1080/00220671.2021.1948382

Ata Baran, A., & Kabael, T. (2023). An investigation of eighth-graders' mathematical communication competency and mathematical literacy performance. *The Journal of Educational Research*, *116*(4), 216–229. https://doi.org/10.1080/00220671.2023.2250752

Awidi, I. T., & Paynter, M. (2019). The impact of a flipped classroom approach on student learning experience. *Computers & education*, *128*, 269-283. https://doi.org/10.1016/j.compedu.2018.09.013

Bal Sarıaltın, N., & Ata Baran, A. (2025). A case study on the mathematical communication competency of mathematically gifted and non-gifted students. *The Journal of Educational Research*, *118*(3), 299–309. https://doi.org/10.1080/00220671.2025.2475310

Cabı, E. (2018). The impact of the flipped classroom model on students' academic achievement. *International review of research in open and distributed learning*, *19*(3). https://doi.org/10.19173/irrodl.v19i3.3482

Cevikbas, M., & Kaiser, G. (2020). Flipped classroom as a reform-oriented approach to teaching mathematics. *Zdm*, *52*(7), 1291-1305. https://doi.org/10.1007/s11858-020-01191-5

Chen, K. S., Monrouxe, L., Lu, Y. H., Jenq, C. C., Chang, Y. J., Chang, Y. C., & Chai, P. Y. C. (2018). Academic outcomes of flipped classroom learning: a meta-analysis. *Medical education*, *52*(9), 910-924. https://doi.org/10.1111/medu.13616

Diego-Mantecon, J. M., Prodromou, T., Lavicza, Z., Blanco, T. F., & Ortiz-Laso, Z. (2021). An attempt to evaluate STEAM project-based instruction from a school mathematics perspective. *ZDM–Mathematics Education*, *53*(5), 1137-1148. https://doi.org/10.1007/s11858-021-01303-9

Engelbrecht, J., Llinares, S., & Borba, M. C. (2020). Transformation of the mathematics classroom with the internet. *Zdm*, *52*(5), 825-841. https://doi.org/10.1007/s11858-020-01176-4

Fauzan, M., Haryadi, H., & Haryati, N. (2021). Penerapan Elaborasi Model Flipped Classroom dan Media Google classroom Sebagai Solusi Pembelajaran Bahasa Indonesia Abad 21. *DWIJA CENDEKIA: Jurnal Riset Pedagogik*, *5*(2), 361-371. https://doi.org/10.20961/jdc.v5i2.55779\

Fernández-Martín, F. D., Romero-Rodríguez, J. M., Gómez-García, G., & Ramos Navas-Parejo, M. (2020). Impact of the flipped classroom method in the mathematical area: A systematic review. *Mathematics*, *8*(12), 2162. https://doi.org/10.3390/math8122162

Godino, J. D., Burgos, M., & Gea, M. M. (2022). Analysing theories of meaning in mathematics education from the onto-semiotic approach. *International Journal of Mathematical Education in Science and Technology*, *53*(10), 2609-2636. https://doi.org/10.1080/0020739X.2021.1896042

Kallia, M., van Borkulo, S. P., Drijvers, P., Barendsen, E., & Tolboom, J. (2021). Characterising computational thinking in mathematics education: a literature-informed Delphi study. *Research in Mathematics Education*, *23*(2), 159–187. https://doi.org/10.1080/14794802.2020.1852104

Khalid, L., Bucheerei, J., & Issah, M. (2021). Pre-service teachers' perceptions of barriers to promoting critical thinking skills in the classroom. *Sage Open*, *11*(3), 21582440211036094. https://doi.org/10.1177/21582440211036094

Kosko, K. W., & Gao, Y. (2017). Mathematical communication in state standards before the common core. *Educational Policy*, *31*(3), 275-302. https://doi.org/10.1177/0895904815595723

Loizou, M., & Lee, K. (2020). A flipped classroom model for inquiry-based learning in primary education context. *Research in Learning Technology*, *28*. https://doi.org/10.25304/rlt.v28.2287

Mingorance Estrada, Á. C., Granda Vera, J., Rojas Ruiz, G., & Alemany Arrebola, I. (2019). Flipped classroom to improve university student centered learning and academic performance. *Social Sciences*, *8*(11), 315. https://doi.org/10.3390/socsci8110315

Morgan, C. (2016). Communicating mathematically. In *Learning to teach mathematics in the secondary school* (pp. 148-163). Routledge. https://doi.org/10.4324/9781315672175-8

Mukhayat, A., Noer, S. H., & Sutiarso, S. (2024). Kemampuan komunikasi dan pemahaman konsep matematika melalui model Flipped Classroom berbantu media pembelajaran. *Indiktika: Jurnal Inovasi Pendidikan Matematika*, *6*(2), 162-172. https://doi.org/10.31851/indiktika.v6i2.15034

Njie-Carr, V. P., Ludeman, E., Lee, M. C., Dordunoo, D., Trocky, N. M., & Jenkins, L. S. (2017). An integrative review of flipped classroom teaching models in nursing education. *Journal of Professional Nursing*, *33*(2), 133-144. https://doi.org/10.1016/j.profnurs.2016.07.001

Nufus, H., & Mursalin, M. (2020). Improving Students' Problem Solving Ability and Mathematical Communication through the Application of Problem Based

Learning. *Electronic Journal of Education, Social Economics and Technology*, *1*(1), 43-48. https://doi.org/10.33122/ejeset.v1i1.8

Nuraida, I., & Amam, A. (2019). Hypothetical learning trajectory in realistic mathematics education to improve the mathematical communication of junior high school students. *Infinity Journal*, *8*(2), 247-258. https://doi.org/10.22460/infinity.v8i2.p247-258

Popovic, G., & Lederman, J. S. (2015). Implications of informal education experiences for mathematics teachers' ability to make connections beyond formal classroom. *School Science and Mathematics*, *115*(3), 129-140. https://doi.org/10.1111/ssm.12114

Rahman, R. A., Yusof, Y. M., Kashefi, H., & Baharun, S. (2012). Developing mathematical communication skills of engineering students. *Procedia-Social and Behavioral Sciences*, *46*, 5541-5547. https://doi.org/10.1016/j.sbspro.2012.06.472

Rahmawati, R. D., Dwiningrum, S. I. A., & Fredy, F. (2022). Determinants of Self Efficacy in Mathematical Communication Elementary School Students. *AL-ISHLAH: Jurnal Pendidikan*, *14*(3), 3693-3704. https://doi.org/10.35445/alishlah.v14i3.1827

Rahmi, S., Nadia, R., Hasibah, B., & Hidayat, W. (2017). The relation between self-efficacy toward math with the math communication competence. *Infinity Journal*, *6*(2), 177-182. https://doi.org/10.22460/infinity.v6i2.p177-182

Rasyid, M. A. (2019). Kemampuan komunikasi matematis dalam pembelajaran matematika. *Jurnal Edukasi: Kajian Ilmu Pendidikan*, *5*(1), 77-86. https://doi.org/10.51836/je.v5i1.116

Reidsema, C., Hadgraft, R., & Kavanagh, L. (2017). Introduction to the flipped classroom. *The flipped classroom: Practice and practices in higher education*, 3-14. https://doi.org/10.1007/978-981-10-3413-8_1

Richter, E., Carpenter, J. P., Meyer, A., & Richter, D. (2022). Instagram as a platform for teacher collaboration and digital social support. *Computers & Education*, *190*, 104624. https://doi.org/10.1016/j.compedu.2022.104624

Ristiana, M. G., Wahyudin, W., Herman, T., & Nurjanah, N. (2025). Analysis of mathematical communication ability on prospective elementary school teachers based on self-regulated learning level. *Infinity Journal*, *14*(3), 607-632. https://doi.org/10.22460/infinity.v14i3.p607-632

Rohid, N., & Rusmawati, R. D. (2019). Students' Mathematical Communication Skills (MCS) in Solving Mathematics Problems: A Case in Indonesian Context. *Anatolian Journal of Education*, *4*(2), 19-30.

Ruswanto, R., Dwijanto, D., & Widowati, W. (2018). A realistic mathematics education model includes characteristic to improve the skill of communication mathematic. *Unnes Journal of Mathematics Education Research*, *7*(1), 94-101. https://journal.unnes.ac.id/sju/ujmer/article/view/24068

Sein-Echaluce, M. L., Fidalgo-Blanco, Á., Balbín, A. M., & García-Peñalvo, F. J. (2024). Flipped Learning 4.0. An extended flipped classroom model with Education 4.0 and organisational learning processes. *Universal access in the information society*, *23*(3), 1001-1013. https://doi.org/10.1007/s10209-022-00945-0

Serra, J. (2023). Mathematical morphology. In *Encyclopedia of mathematical geosciences* (pp. 820-835). Cham: Springer International Publishing.

Shyr, W. J., & Chen, C. H. (2018). Designing a technology-enhanced flipped learning system to facilitate students' self-regulation and performance. *Journal of Computer assisted learning*, *34*(1), 53-62. https://doi.org/10.1111/jcal.12213

Simon, M. A. (2017). Explicating mathematical concept and mathematicalconception as theoretical constructs for mathematics education research. *Educational Studies in Mathematics*, *94*, 117-137. https://doi.org/10.1007/s10649-016-9728-1

Teledahl, A. (2017). How young students communicate their mathematical problem solving in writing. *International journal of mathematical education in science and technology*, *48*(4), 555-572. https://doi.org/10.1080/10986060802291642

Tinungki, G. M., Hartono, P. G., Nurwahyu, B., Islamiyati, A., Robiyanto, R., Hartono, A. B., & Raya, M. Y. (2024). Exploring the team-assisted individualization cooperative learning to enhance mathematical problem solving, communication and self-proficiency in teaching non-parametric statistics. *Cogent Education*, *11*(1). https://doi.org/10.1080/2331186X.2024.2381333

Tong, D. H., Uyen, B. P., & Quoc, N. V. A. (2021). The improvement of 10th students' mathematical communication skills through learning ellipse topics. *Heliyon*, *7*(11). https://doi.org/10.1016/j.heliyon.2021.e08282

Vos, P. (2018). "How real people really need mathematics in the real world"—Authenticity in mathematics education. *Education Sciences*, *8*(4), 195. https://doi.org/10.3390/educsci8040195

Wang, Y., Huang, X., Schunn, C. D., Zou, Y., & Ai, W. (2019). Redesigning flipped classrooms: a learning model and its effects on student perceptions. *Higher Education*, *78*, 711-728. https://doi.org/10.1007/s10734-019-00366-8

Widjajanti, D. B. (2013). The communication skills and mathematical connections of prospective mathematics teacher: A case study on mathematics education students, Yogyakarta State University, Indonesia. *Jurnal Teknologi (Sciences & Engineering)*, *63*(2). https://doi.org/10.11113/jt.v63.2003

Yaniawati, R. P., Indrawan, R., & Setiawan, G. (2019). Core Model on Improving Mathematical Communication and Connection, Analysis of Students' Mathematical Disposition. *International Journal of Instruction*, *12*(4), 639-654.