JTAM (Jurnal Teori dan Aplikasi Matematika)
http://journal.ummat.ac.id/index.php/jtam
p-ISSN 2597-7512 | e-ISSN 2614-1175
Vol. 7, No. 2, April 2023, pp. 443-451

Developing Mathematics Written Communication through Case-Based Learning

Joko Suratno[1], Ikram Hamid[2], Ida Kurnia Waliyanti[3]
[1,2,3]Mathematics Education, Universitas Khairun, Indonesia
joko_unkhair@yahoo.co.id[1]; ikram_hm21@yahoo.co.id[2], adhinku@gmail.com[3]

Article History:
Received : 23-01-2023
Revised : 18-03-2023
Accepted : 27-03-2023
Online : 06-04-2023

Keywords:
Case-based learning;
Mathematical communication.

ABSTRACT

Mathematical education, as it is now practiced, has many problems. Students that were taught using traditional instruction were only taught to listen. Without the input and feedback of the pupils, the teacher controls the learning process. Students were unable to improve their communication abilities and lacked learning independence. This study aimed to ascertain how case-based learning affected students' mathematics communication skills. The study had a posttest-only design and was a quasi-experimental investigation. The control class received standard instruction, whereas the experiment class received case-based learning instruction. The ability of students to communicate mathematically was the dependent variable in this study. The independent variables in this study were case-based learning and independent variables. Forty-six pre-service mathematics teachers from two full classes served as the research participants in their fifth semester. The tests of prior knowledge and mathematical communication skills were used as study tools. According to the research findings, there is a difference in students' capacity for mathematical communication between those who receive case-based learning instruction and those who receive traditional instruction. The experiment class had better student communication skills than the control group (p-value = 0.047). As a result, case-based learning is one option for enhancing students' communication abilities.

Crossref
https://doi.org/10.31764/jtam.v7i2.13318

——————————— ◆ ———————————

A. INTRODUCTION

Communication is a crucial component of the reasoning process for individuals working with previously generated texts to create new ones and for groups working together to produce an argument (Brodie, 2010). Through dialogue, students will organize and strengthen their thinking abilities as they learn. Additionally, students must use straightforward language to convey their thoughts while thinking critically about problems. Language and math studies are built on the study of communication (Kennedy et al., 2008). Language and communication are, therefore crucial components of arithmetic learning.

Students need to be able to think and communicate mathematically to solve mathematical problems. The main objective of modern teaching and learning initiatives is to help students develop their problem-solving skills Koehler & Vilarinho-Pereira (2021), and developing pupils' problem-solving skills is a crucial objective of mathematics education (Hourigan & Leavy, 2022). It is possible to clarify concepts or exchange ideas using mathematical communication. Students will learn to correctly explain and use mathematical terminology when asked to articulate their concepts vocally. There are three distinct components to mathematical communication. Communication about mathematics, communication within mathematics, and communication with mathematics are some of these elements. In education, the usage of student-centered learning environments has grown (Baeten et al., 2016). Someone must communicate their thought process and problem-solving strategy while communicating about mathematics. The students need to externalize the process that might not happen when working alone in a traditional learning environment. As a result of dialogue in the classroom, the externalization process may support high-level reasoning. In mathematics, communication is defined as the use of language with mathematical symbols. How language is used when discussing mathematics is directly tied to the mathematical language style; communicating about mathematics is connected to using mathematics, which enables students to solve issues.

One of the learning models frequently used in classroom activities is the traditional one. This model starts with the instructor explaining an idea or topic. Before continuing with their practice, the teacher walks the students through the steps required to complete a task or problem. Teachers with extra concerns may further explain these steps (Chapko & Buchko, 2004). In this study, teachers actively participate in classroom activities, whereas passive pupils take the lectures (Aziz & Hossain, 2010). When the teacher merely acts as a conduit for knowledge, the learning activities are frequently referred to as one-way learning. Students' input and feedback are useless if a teacher is the only person driving the learning process. Sometimes the only resources provided are books and learning notes. Additionally, learning activities lack practical activities, teacher handwriting is not a reliable indicator of the clarity of the material because of its quality, there is insufficient student interaction in the classroom, existing theories are emphasized more than real-world situations and situations, learning is done by memorization rather than understanding, and learning is results-oriented (Damodharan & Rengarajan, 2007).

With traditional education, pupils become listeners rather than learners. Students must therefore learn to be more independent. Lessons are exclusively given to students by the teacher. Students cannot perform to the best of their abilities in class due to time constraints. Students, on the other hand, need to be able to control their learning. Learning quality and its potential improve when students learn to manage their time better. Independent learners are actively involved in optimizing their learning chances and capacities (Darr & Fisher, 2004). This makes sense, given that regulated learning involves students actively designing their learning objectives and then attempting to monitor, sustain, and monitor their awareness, motivation, and behavior that is guided and constrained by those objectives while highlighting the context in the environment (Pintrich, 2000). Students' quality cannot improve if traditional learning is always used to give material courses. Students will always be dependent on the teacher and require assistance in determining how to raise their level of performance.

Thus, the use of multimedia and many strategies by teachers is mandated by curriculum reform. Case-based learning is an alternative teaching method that may be employed. A teaching strategy known as "case-based learning" requires students to actively engage in real-world or hypothetical issue situations that reflect the experiences frequently encountered in the topic being studied (Ertmer & Russell, 1995). The Latin word cases, which means "occurrence" or "something that happens," is where the term "case" originates. A case's main objective is to force pupils to confront complex, unstructured situations and consider potential answers. Cases may be fiction or creative works that aim to describe actual circumstances accurately. In most situations, these components are combined in the design and narrative (Morrison, 2001). The following are the steps in case-based learning. The case is presented, the group examines it, brainstorms ideas, develops learning objectives, sorts the research, presents the findings, and students reflect (Williams in Stanley, 2021).

Dorit Alt (2020) stated that Case-based learning is a successful instructional strategy for enhancing students' capacity to apply the knowledge, concepts, and abilities they have acquired in the classroom to real-world situations. Case-based learning improves students' capacity for resolving ill-structured problems (Rong & Choi, 2019). For the transfer of learning in ill-structured problem solving, case-based learning as a whole learning environment was beneficial (Choi & Lee, 2009). To assist educators in developing more productive case-based learning environments, suggestions for instructional design about the use of failure scenarios are presented based on discussions of the study's findings (Rong et al., 2020). Case-based learning differs from problem-based learning; problem-based learning sessions often need more guidance for case discussion. Students needed more time to prepare and frequently did their study as the case was presented; thus, learning happened as it happened. Problem-based learning the student needed more guidance during the case discussion and initial preparation. However, with case-based learning, practice is done in advance by both the instructor and the students, and there is a direction for the debate to ensure that crucial learning elements are covered (McLean, 2016).

A case is frequently presented as a narrative with a clear framework, a significant character, specimen, or element, where a problem needs to be solved. Cases generally resemble real-life events (Kulak, 2014). Using scenarios based on real-world educational problems, case study-based instruction helps instructors to engage students in the reality of teaching (Willems et al., 2021). Students can problem-solve varied outcomes and produce potential answers from various theoretical stances. Instances are conceptualized in ways beyond the conventional framework of cases as human experiences and contain phenomena crucial to comprehending complex ideas about perspective and space (Valentine & Kopcha, 2016). In the CBL group, students demonstrated high satisfaction and problem-solving skills (Bi et al., 2019). The problem in CBL is an ill-structured problem or open-ended problem, and Open-ended problems encourage more inventiveness and inspire a more extensive range of learners (Allchin, 2017).

Baeten et al. (2013) stated that compared to students who solely engaged in case-based learning, students in a gradually implemented case-based setting worked more efficiently and with greater focus. Additionally, student participation in case-based activities scored much better on the more typical, algorithmic in-course exams (Fawcett, 2017). The majority of students felt that they learned positive attitudes throughout the course and had favorable opinions of CBL as a teaching strategy, according to the results (Watson et al., 2022). Çam and Geban (2011), in their research, stated that the findings revealed a substantial difference in views regarding school subjects between the experimental and control groups, favoring the group using a case-based learning approach. According to case-based reasoning, comprehension and interpretation of a case are incremental and dynamic; hence, the lessons learned from one case may alter throughout a case-based curriculum and in light of new experiences (Tawfik et al., 2019).

Since each student hopes to succeed in their academic endeavors, this research is crucial to finding solutions to issues. According to one study, students who were taught using case-based learning methodologies behaved significantly different than those who were not (Akanmu & Fajemidagba, 2012). There was much research that stressed teacher-student communication. However, more study was required to determine how case-based learning affected students' mathematical communication abilities, particularly in geometry.

B. METHODS

Quasi-experimental research methodology is employed. The primary distinction between this study and actual experimental research is the grouping of participants. To reduce bias in experimental investigations, participants were recruited at random. Quasi-experimental research is the best option if the individual selection is considered problematic or impossible. Because the quasi-experimental design does not offer total control, researchers must be mindful of variables that impact internal and external validity when interpreting their research findings (Suratno et al., 2018). The dependent variables in this study are mathematical communication abilities, while the independent factors are case-based learning. In this work, a post-test-only design with no equivalent groups was the basis for the quasi-experimental methodology.

$$\frac{NR \quad X \quad O_1}{NR \qquad\;\; O_2}$$

Notes:

NR	=	Non-random (Not Random)
X	=	Case-based Learning
$O_1 = O_2$	=	Mathematical Communication Ability

The experimental and control sample classes are separated by a dashed line, indicating that the experimental and control sample classes were not created by randomly assigning individuals or study participants to the sample classes. Forty-six pre-service mathematics teachers from two complete classes were the study's participants in the fifth semester. Case-based learning is used to teach students enrolled in the experimental class. The control class, in contrast, imparts traditional instruction to the students who served as the research subjects. With more outstanding direction, the instructor offers case-based learning services (Stanley, 2021). After the learning sessions, students in both sample classes took a test ($O_1 = O_2$) to assess their communication skills.

C. RESULT AND DISCUSSION

All grade levels indeed have varied mathematical communication skills. Students should be able to organize and consolidate their mathematical thinking skills through communication, communicate their mathematical thinking coherently and clearly to peers, teachers, and others, analyze and evaluate the mathematical thinking strategies of others, and use mathematical language to demonstrate mathematical ideas precisely in educational programs from kindergarten through Grade 12. It is essential to employ communication tools to improve pupils' communication abilities. Reading (numbers, graphs), writing (numbers), extracting information from media, translating information from media, interpreting information from media, and presenting information are some examples of communication abilities (tables, charts, graphs). Additionally, there are three different ways to communicate: orally, in writing, and physically (Morgan et al., 2004).

The communication abilities used to present data or mathematical issues in writing were tested in this study. The written language, symbols, diagrams used in mathematics textbooks, and verbal/spoken classroom engagement all contribute to the construction of particular beliefs about the nature of mathematics and expectations for student's participation in the mathematical activity (Alshwaikh & Morgan, 2018). The average and standard deviation can describe the students' mathematical communication abilities. The following is an overview of students' mathematical communication skills, as shown in Table 1.

Table 1. Description of Students' Mathematical Communication Ability

Treatment	Mean	Std. Deviation	N
CBL	63,33	13,884	24
Conventional	55,45	8,579	22

There were 46 students in case-based learning (CBL) and traditional classes. The standard deviation of the student's mathematical communication abilities in CBL class was 13,884; the average was 63,33. However, in a control classroom, the mean student's mathematical communication skill was 55,45, with a standard deviation of 8,579. The standard deviation for both groups was 12,194, and their average was 59,57. The range of student mathematical communication ability is 0 to 100, so both the CBL and conventional classes can be categorized as having moderate mathematical communication ability.

The normality test of the learning-based data revealed that the Kolmogorov-Smirnov test's p-value for both the CBL and traditional classes was more significant than (> 0.05). A p-value of < 0.05 was found for the CBL and Control classes in the test of homogeneity of variance. As a result, both test-based learning systems used data on students' mathematical communication skills drawn from a normally distributed sample. Data on students' mathematical communication, however, do not homogen. The statistical test utilized in this analysis is a nonparametric test based on the normality test and homogeneity of variance of student data on mathematical communication skills. The Mann-Whitney test is the nonparametric test that is employed. The independent two-sample t-test can be substituted with the Mann-Whitney test, as shown in Table 2.

Table 2. Mann-Whitney Test Results

Treatment	Mean Rank	Mann-Whitney U	Z	Asymp. Sig. (2-tailed)
CBL	27,23	174,5	-1,988	0.047
Traditional	19,43			

Table 2 shows that the factor of the learning approach has a p-value < 0.05. It means that case-based learning has affected the ability of students' mathematical communication. The communication abilities used to present data or mathematical issues in writing were tested in this study. Written communication involves more than just relaying what the author was thinking to the reader's mind. The creation and interpretation of the article will be influenced by the writers' and readers' perceptions of the topics under discussion. In this investigation, various interpretations might be made. Researchers divide students' mathematics communication abilities into two categories: moderate and low. What pupils express through their writing may not be the same as how they feel. The findings also indicated that case-based instruction impacts students' mathematics communication skills. Because case-based learning (CBL) affects mathematics more strongly than traditional learning, it impacts students' mathematical communication skills. Better learning results, student engagement in the classroom, and attitudes toward mathematics demonstrated this. However, the findings of this study have demonstrated how much pupils have learned about the subject matter. What the students know and do not know must be communicated in writing through the test answer sheets.

Written communication is one type of communication. One aspect of textual communication that should be looked into is a generalization. For instance, the Southern Examining Group described the GCSE candidates' work at various grade levels: Make an effort to generalize; make an effort to generalize and, with advice, express it in words; make an effort to generalize and express it in words and, with guidance, in symbols; make an effort to generalize and express it in symbols.

The test evaluates a student's capacity to generalize. They must investigate and analyze the line characteristics resulting from the intersection of the diagonal, median, and parallel lines with the sides of the trapezoid. Students' responses to questions involving the drawing of a right-angled trapezoid ABCD with the conditions that the trapezoid bracket at point A, the length of the side AB being twice as long as the DC, and the AB being parallel to the DC are used to assess student's written communication skills; drawing the diagonals AC and DB, noting the point P's name where they cross; The median line of ADB, which intersects the diagonal AC at point E, should be drawn as line segment DM; Create a parallel line through point E to the sides AB and, then progressively cross line segments AD, DB, and BC at points H, F, and G, as shown in Figure 1.

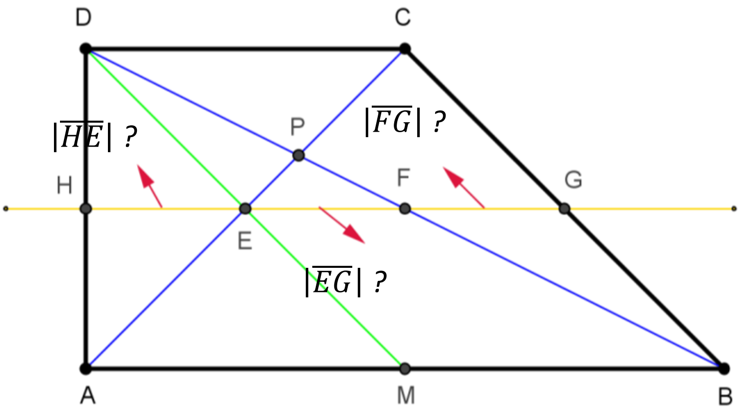

Figure 1. Illustration of Investigation Task

Although most students were still working on it, it needed to be finished. Some pupils drew a trapezoid that did not adhere to the guidelines, while others drew a triangle. Another trapezoidal has an inaccurate name, such trapezoid ABDC. Some pupils, however, are tackling this problem reasonably adeptly, as shown in Figure 2.

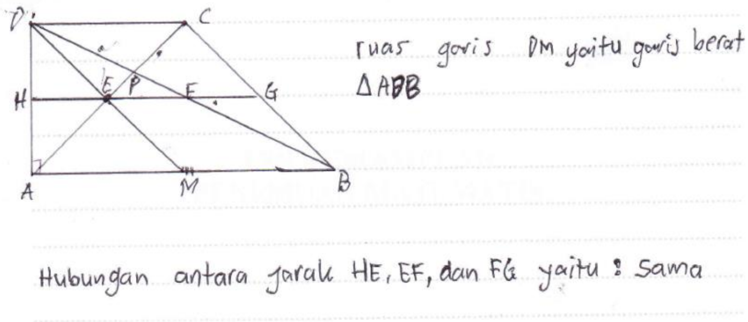

Figure 2. Example of Students' Work

The student in Figure 2 provides the best response for all students. However, there are a few things that need to be criticized. Critics should point out that the alignment between the AB and DC sides is not permanent and that the DC, AM, and MB do not have equal-length signs. Additionally, no information states that students measure the HE, EF, and FG distances. This task requires measurement accuracy since, if completed, students will complete a measuring activity to discover the appropriate solution.

D. CONCLUSION AND SUGGESTIONS

The exploration of mathematical concepts by students is greatly aided through communication. To encourage students to think and reason about what they are doing, a setting can be provided where they can converse about mathematics. Students should be encouraged to communicate with one another to practice expressing and clarifying their ideas and become more objective. One sign of a teacher's ability to effectively direct learning activities is communication in the classroom. However, communication should take place not just in the classroom but also in a broader social setting. For instance, students should still be able to connect with her via a discussion board or collaborative assignment projects. Homework is a social communication tool that children can use to connect with their parents.

This study demonstrates how case-based learning techniques impact students' mathematics communication skills. Therefore, it is essential that case-based learning be used as a substitute in order to enhance communication and fulfill learning objectives. Case-based learning is a constructivist learning design paradigm that blends radical constructivism with constructivism learning design theory and the concepts of learning with discovery. A postmodern philosophy of knowing called constructivism has the potential to alter educational thought. Additionally, constructivism is a theory of knowledge and a learning theory. There were noticeable behavioral changes between students taught using case-based learning methodologies and those taught without them. The experiment class had better student communication skills than the control group. As a result, case-based learning is one option for enhancing students' communication abilities.

REFERENCES

Akanmu, M. A., & Fajemidagba, M. O. (2012). Guided-discovery learning strategy and senior school students performance in mathematics in Ejigbo, Nigeria. *Journal of Education and Practice*, *4*(12), 82–90. https://www.iiste.org/Journals/index.php/JEP/article/view/6515/6484

Allchin, D. (2017). Problem- and Case-Based Learning in Science: An Introduction to Distinctions, Values, and Outcomes. *CBE—Life Sciences Education*, *12*(3). https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3763004/

Alshwaikh, J., & Morgan, C. (2018). A framework for the study of written and spoken discourse: school mathematics in Palestine. *ZDM*, *50*, 1041–1051. https://link.springer.com/article/10.1007/s11858-018-0970-0

Aziz, Z., & Hossain, M. A. (2010). A comparison of cooperative learning and conventional teaching on students' achievement in secondary mathematics. *Procedia Social and Behavioral Sciences*, *9*, 53–62. https://www.sciencedirect.com/science/article/pii/S1877042810022202

Baeten, M., Dochy, F., & Struyven, K. (2013). Enhancing students' approaches to learning: the added value of gradually implementing case-based learning. *European Journal of Psychology of Education*, *28*, 315–336. https://link.springer.com/article/10.1007/s10212-012-0116-7

Baeten, M., Dochy, F., Struyven, K., Parmentier, E., & Vanderbruggen, A. (2016). Student-centred learning environments: an investigation into student teachers' instructional preferences and approaches to learning. *Learning Environments Research*, *19*, 43–62. https://link.springer.com/article/10.1007/s10984-015-9190-5

Bi, M., Zhao, Z., Yang, J., & Wang, Y. (2019). Comparison of case-based learning and traditional method in teaching postgraduate students of medical oncology. *Medical Teacher*, *41*(10), 1124–1128. https://pubmed.ncbi.nlm.nih.gov/31215320/

Brodie, K. (2010). *Teaching mathematical reasoning in secondary school classrooms*. Springer.

Çam, A., & Geban, Ö. (2011). Effectiveness of Case-Based Learning Instruction on Epistemological Beliefs and Attitudes Toward Chemistry. *Journal of Science Education and Technology*, *20*, 26–32. https://link.springer.com/article/10.1007/s10956-010-9231-x

Chapko, M. A., & Buchko, M. (2004). Math Instruction for Inquiring Minds: Two Principals Explain Why They Turned From Conventional Math Instruction to an Approach that Focuses on Understanding and Applying Math Concepts. *Principal*, *84*(2), 30–33. https://eric.ed.gov/?id=EJ693872

Choi, I., & Lee, K. (2009). Designing and implementing a case-based learning environment for enhancing ill-structured problem solving: classroom management problems for prospective teachers. *Educational Technology Research and Development*, *57*, 99–129. https://link.springer.com/article/10.1007/s11423-008-9089-2

Damodharan, V. S., & Rengarajan, V. (2007). *Innovative methods of teaching*. http://math.arizona.edu/~atp-mena/conference/proceedings/Damodharan_Innovative_Methods.pdf

Darr, C., & Fisher, J. (2004). Self-regulated learning in the mathematics class. *NZARE Conference*. https://www.nzcer.org.nz/system/files/journals/set/downloads/set2005_2_044_0.pdf

Ertmer, P. A., & Russell, J. D. (1995). Using case studies to enhance instructional design. *Educational Technology*, *35*(4), 23–31. https://www.jstor.org/stable/44428285

Fawcett, L. (2017). The CASE Project: Evaluation of Case-Based Approaches to Learning and Teaching in Statistics Service Courses. *Journal of Statistics Education*, *25*(2), 79–89. https://www.tandfonline.com/doi/full/10.1080/10691898.2017.1341286

Hourigan, M., & Leavy, A. M. (2022). Elementary teachers' experience of engaging with Teaching Through Problem Solving using Lesson Study. *Mathematics Education Research Journal*. https://link.springer.com/article/10.1007/s13394-022-00418-w

Kennedy, L. M., Tipps, S., & Johnson, A. (2008). *Guiding Children's Learning Mathematics* (11th ed.). Thomson Wadsworth.

Koehler, A. A., & Vilarinho-Pereira, D. R. (2021). Using social media affordances to support Ill-structured problem-solving skills: considering possibilities and challenges. *Educational Technology Research and Development*. https://link.springer.com/article/10.1007/s11423-021-10060-1

Kulak, V. (2014). A guide to using case-based learning in biochemistry education. *Biochemistry and Molecular Biology Education*, *42*(6). https://pubmed.ncbi.nlm.nih.gov/25345695/

McLean, S. F. (2016). Case-Based Learning and its Application in Medical and Health-Care Fields: A Review of Worldwide Literature. *Journal of Medical Education and Curricular Development*, *3*. https://pubmed.ncbi.nlm.nih.gov/29349306/

Morgan, C., Watson, A., & Tikly, C. (2004). *Teaching school 11-19: Mathematics*. RotledgeFalmer.

Morrison, T. (2001). *Actionable Learning: A Handbook for Capacity Building Through Cased Based Learning*. Asian Development Bank Institute.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of Self-Regulation* (pp. 451–502). Academic Press. https://www.sciencedirect.com/science/article/pii/B9780121098902500433

Rong, H., & Choi, I. (2019). Integrating failure in case-based learning: a conceptual framework for failure classification and its instructional implications. *Educational Technology Research and Development*, *67*, 617–637. https://link.springer.com/article/10.1007/s11423-018-9629-3

Rong, H., Choi, I., Schmiedt, C., & Clarke, K. (2020). Using failure cases to promote veterinary students' problem-solving abilities: a qualitative study. *Educational Technology Research and Development*, *68*, 2121–2146. https://link.springer.com/article/10.1007/s11423-020-09751-y

Stanley, T. (2021). *Project-Based Learning for Gifted Students: A Step-by-Step Guide to PBL and Inquiry in the Classroom*. Routledge.

Suratno, J., Ardiana, & Tonra, W. S. (2018). Computer-assisted guided discovery learning of algebra. *Journal of Physics: Conference Series*, *1028*(1). https://doi.org/10.1088/1742-6596/1028/1/012132

Tawfik, A. A., Fowlin, J., Kelley, K., Anderson, M., & Vann, S. W. (2019). Supporting Case-Based Reasoning in Pharmacy Through Case Sequencing. *Journal of Formative Design in Learning*, *3*, 111–122. https://link.springer.com/article/10.1007/s41686-019-00035-0

Valentine, K. D., & Kopcha, T. J. (2016). The embodiment of cases as alternative perspective in a mathematics hypermedia learning environment. *Educational Technology Research and Development* , *64*, 1183–1206. https://link.springer.com/article/10.1007/s11423-016-9443-8

Watson, W. R., Watson, S. L., Koehler, A. A., & Oh, K. H. (2022). Student profiles and attitudes towards case-based learning in an online graduate instructional design course. *Journal of Computing in Higher Education*. https://link.springer.com/article/10.1007/s12528-022-09339-w

Willems, P. P., Gonzalez-DeHass, A. R., Powers, J. R., & Musgrove, A. (2021). The role of authentic teaching cases and mastery approach goals in online pre-service teachers' self-regulated learning. *Educational Technology Research and Development Volume*, *69*, 1003–1023. https://link.springer.com/article/10.1007/s11423-021-09972-9