

EFFECTS OF GENERATIVE TEACHING STRATEGY ON SELF-EFFICACY AND SELF-REGULATION IN LEARNING GEOMETRY AMONG SENIOR SECONDARY SCHOOL STUDENTS IN MAIDUGURI METROPOLIS, BORNO STATE, NIGERIA

Muktar, B.

Department of Science Education,
Federal University of Technology, Minna
bbgmuk@futminna.edu.ng | 08024788826

Shuaibu, G.

Department of Science Education,
Bayero University, Kano

Ahmed, D.

Kaduna State College of Education, Gidan Waya Kafancan, Kaduna

&

Gali, H. A.

Department of Mathematics Education,
Yusuf Maitama Sule Federal University of Education, Kano

Abstract

This study investigated the effects of a generative teaching strategy (GTS) on self-efficacy and self-regulation in learning geometry among Senior Secondary School (SS II) students. Utilising a quasi-experimental, pre-test/post-test non-equivalent control group design, 106 SS II students were divided into an experimental group ($N = 52$) exposed to GTS and a control group ($N = 54$) taught using conventional methods. The Geometry Self-Efficacy and Self-Regulation Questionnaire (GSSQ) was administered before and after a six-week intervention. Data analysis using median, mean rank, and Mann-Whitney U -tests revealed statistically significant differences between the groups. The experimental group showed significantly higher post-intervention self-efficacy (median = 14, IQR = 3) compared to the control group (median = 9, IQR = 2) ($U = 5$, $p = .001$, $r = 0.86$). Similarly, self-regulation scores were significantly higher in the experimental group (median = 17, IQR = 3) than in the control group (median = 10, IQR = 2) ($U = 3$, $p = .001$, $r = 0.86$). Furthermore, within the experimental group, post-intervention self-regulation scores were significantly higher than self-efficacy scores ($Z = 5.319$, $p < .001$, $r = 0.52$). These findings suggest that generative teaching strategies significantly enhance both self-efficacy and self-regulation in geometry learning. The study recommends integrating GTS into the geometry aspect of the mathematics curriculum.

Keywords: Generative teaching strategy, self-efficacy, self-regulation, geometry, senior secondary school students.

Introduction

Geometry holds an important position within the secondary school Mathematics curriculum. It is crucial for

developing spatial reasoning, logical deduction, and critical thinking skills (Jablonski & Ludwig, 2023). Its extensive applications across science,



technology, and engineering highlight its importance for national scientific and technological advancement, particularly in developing nations like Nigeria. A strong foundation in geometry is therefore not merely an academic requirement but a vital component of a student's intellectual and professional development.

However, despite its undeniable importance, a persistent and troubling chasm exists between the significance of geometry and the reality of student engagement and success. Senior secondary school students frequently approach geometry with pronounced apprehension and struggle to master its abstract concepts and rigorous, proof-based demands (Aboagye, Ke, & Mante, 2021; Machisi, 2021). This widespread difficulty indicates that traditional, transmission-based instructional models, which position students as passive recipients of information, are failing to equip learners with the essential psychological and metacognitive tools required for success.

A central facet of this failure is students' low self-efficacy. Self-efficacy is defined as an individual's conviction in their capacity to organise and execute the courses of action required to achieve specific goals, such as solving geometric problems (Bandura, 1997; Bradley, Browne, & Kelley, 2017). When students are plagued by doubts about their mathematical abilities, they are less likely to embrace challenging tasks, persist through difficulties, or invest sustained effort. This creates a self-fulfilling prophecy where low confidence leads to avoidance and poor performance, which in turn further erodes confidence (Juman et al., 2022; Mata, Monteiro, & Peixoto, 2012).

Compounding this crisis of confidence is a parallel deficit in self-regulation. self-regulation refers to the ability to oversee and direct one's own learning processes through goal-setting, strategic planning, self-monitoring, and self-reflection (Bradley et al., 2017; Mkenda, 2022; Santos, 2022). Geometry, with its multi-step proofs and need for strategic flexibility, demands high levels of these metacognitive skills. Yet, students often lack the capacity to plan their problem-solving approach, monitor their developing understanding, or evaluate the effectiveness of their strategies (Jelatu, Sariyasa, & Ardana, 2018; Santos, 2022). This lack of internal management is a primary reason why many students fail to achieve deep, transferable learning in geometry.

The interplay between these constructs is critical; students who believe in their capabilities are more likely to adopt self-regulatory behaviours, and successful self-regulation reinforces self-efficacy (Bradley et al., 2017). This synergy suggests that interventions targeting both constructs simultaneously could yield compounded benefits. In response to these challenges, generative teaching strategy (GTS) has emerged as a promising pedagogical approach. These strategies actively involve students in constructing their own knowledge through meaningful learning experiences, championing understanding over rote memorisation by encouraging connections between new and existing knowledge (Wang, 2017). Generative techniques, such as concept mapping, peer teaching, and reflective journaling, are theorised to create supportive learning environments that enhance self-efficacy by providing mastery experiences and foster self-regulation by

prompting active engagement and metacognitive awareness (Liu, 2023; Mkenda, 2022).

However, while the benefits of GTS for engagement and comprehension are established, and the individual importance of self-efficacy and self-regulation is well-documented, a critical gap exists in understanding whether GTS can *simultaneously* cultivate both of these foundational psychological constructs in the context of geometry. It remains unknown if GTS has a differential impact on self-efficacy versus self-regulation, and whether its influence is potent enough to counteract the documented challenges in a specific context like Nigerian senior secondary schools. Without this knowledge, educators lack evidence-based guidance on whether GTS is a comprehensive solution for fostering the autonomous, confident learners that geometry demands.

This study, therefore, aims to bridge this gap by examining the specific effects of a generative teaching strategy on both self-efficacy and self-regulation in learning geometry among senior secondary school students in Nigeria. The research seeks to provide empirical evidence to inform the development of more effective instructional practices that address not only content knowledge but also the crucial psychological drivers of learning.

Statement of the Problem

Geometry is a vital subject for developing logical reasoning, yet many senior secondary school students in Nigeria find its abstract nature challenging. This difficulty is primarily related to low self-efficacy and poor self-regulation, which are key internal factors for academic success. While

these concepts are well-explored, there is a notable lack of research on how specific, innovative teaching methods like the Generative Teaching Strategy (GTS) can effectively improve both self-efficacy and self-regulation simultaneously in a geometry classroom. Traditional, teacher-centred approaches have proven inadequate in fostering these essential qualities, resulting in a cycle of underperformance and disengagement. Consequently, this study is necessary to assess the effects of GTS on these two variables, thereby providing evidence-based insights for instructional practices that can enhance student confidence and autonomous learning in geometry.

Research Objectives

The objectives of the study were to:

1. determine the effects of the generative teaching strategy on students' self-efficacy in geometry.
2. assess the effect of the generative teaching strategy on students' self-regulation in geometry.
3. examine the difference between students' geometry self-efficacy and self-regulation score when exposed to generative teaching strategy.

Research Questions

The following research questions were raised to guide the study:

1. What is the difference in geometry self-efficacy scores between students taught using the generative teaching strategy and those taught using conventional methods?
2. What is the difference in geometry self-regulation scores between students taught using the generative teaching strategy

and those taught using conventional methods?

3. What is the difference between students' geometry self-efficacy and self-regulation scores when exposed to generative teaching strategy?

Null Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

H₀₁: There is no significant difference in the post geometry self-efficacy scores between students taught using the generative teaching strategy and those taught using conventional methods.

H₀₂: There is no significant difference in the post geometry self-regulation scores between students taught using the generative teaching strategy and those taught using conventional methods.

H₀₃: There is no significant difference between students' geometry self-efficacy and self-regulation scores when exposed to generative teaching strategy.

Methodology

Research Design

A quasi-experimental research design was adopted for this study, specifically employing a pre-test/post-test non-equivalent control group design. Quasi-experimental designs are effective for establishing cause-and-effect relationships in real-world settings where randomisation may not be feasible Gopalan et al. (2020). This design enables researchers to compare outcomes from different groups without excessively manipulating environmental variables, thereby enhancing the external validity of the findings. In this study, two existing intact classes from selected schools were utilised as the experimental and control groups, with the experimental group receiving instruction through the GTS, while the

control group followed conventional teaching methods. The detailed structure of the research design is represented in Figure 3.1, indicating the flow from pre-test to post-test and subsequent retention measurement through post-post-testing.

Population and Sample

The population of the study consisted of 3,468 Senior Secondary School Year Two (SS II) students across public coeducational schools in Maiduguri Metropolis. The demographic profile comprises approximately 1,902 males and 1,566 females, primarily from the Kanuri and Babur Bura tribes. The sampling technique employed was simple random sampling, aimed at ensuring an equitable selection process whereby every school had an equal opportunity of being chosen. From this population, a sample size of 106 students was determined, with 52 participants from the experimental group and 54 from the control group. This stratified approach aimed to capture the representativeness of the population while also focusing on the specific characteristics of the target demographic.

Research Instruments

The study employed a Geometry Self-Efficacy and Self-Regulation Questionnaire (GSSQ), adapted from the Mathematics Motivation Questionnaire (MMQ) by Fiorella et al. (Zetriuslita et al., 2020). The GSSQ consists of 8 items designed to measure students' self-efficacy and self-regulation in geometry learning. The instrument was administered prior to intervention (pre-test) and following the treatment phase (post-test) to both groups to assess changes in self-efficacy and self-regulation in learning geometry. The scoring system utilised a 5-point Likert scale for responses, allowing for a granular measurement of self-efficacy and self-regulation (Zetriuslita et al., 2020).

Validity and Reliability of the Instrument

The validity of the GSSQ was established through a rigorous validation process involving academic experts from pertinent fields. Their evaluations ensured that the instruments measured the intended constructs with clarity and relevance. The reliability of the GSSQ was determined via pilot testing, with a reliability coefficient of 0.79 obtained through Cronbach's Alpha, ensuring that the instrument maintains internal consistency over repeated measurements (Zetriuslita et al., 2020). This careful validation process was crucial in affirming the credibility of the research findings.

Procedure for Data Collection

Data collection involved a systematic approach to ensure a reliable and unbiased process. Initially, the researcher secured necessary permissions from the relevant educational authorities and introduced the study to principals and mathematics educators. The sample selection of schools and classes was achieved through random assignment, ensuring that each had an equal opportunity for involvement. During the first week, the GSSQ was administered as a pre-test to gauge initial self-efficacy and self-regulation levels in both groups. Subsequently, the experimental group

received instruction under the GTS framework for six weeks, while the control group adhered to the conventional teaching method. After the treatment period, a post-test was administered to assess the immediate impact on student learning outcomes.

Method of Data Analysis

Due to violations of parametric test assumptions, non-parametric statistical methods were exclusively employed, using the median and Interquartile Range (IQR) for descriptive statistics to accurately represent the central tendency and spread of non-normally distributed data. The Mann-Whitney U-test was utilised to assess differences between independent experimental and control groups, while the Wilcoxon Signed-Rank Test evaluated changes within dependent groups over time, both at a 0.05 significance level, thus providing a framework for evaluating the generative teaching strategy's impact on geometry learning outcomes.

Results

Research Question 1: What is the difference in geometry self-efficacy scores between students taught using the generative teaching strategy and those taught using conventional methods?

Table 1: Median Self-Efficacy Scores Before and After Instruction by Teaching Strategy

Group	Pre_Self-efficacy			Post_Self-efficacy		Med. Diff.	Remark
	N	Mdn	IQR	Mdn	IQR		
Experimental	52	10	2	14	3	4	Substantial gain in self-efficacy post-intervention.
Control	54	11	2	9	2	2	Decrease in self-efficacy post-intervention.
Total	106						

Table 1 shows the median self-efficacy scores before and after the intervention for both the experimental and control groups. Before the intervention, the experimental group ($N = 52$) had a median self-efficacy score of 10 (IQR = 2), while the control group ($N = 53$) scored a median of 11 (IQR = 2). After the intervention, the experimental group's median self-efficacy increased to

14 (IQR = 3), with a median difference of 4 and a median gain of 3. Conversely, the control group's median self-efficacy dropped to 9 (IQR = 2), showing a median difference of 2.

H₀₁: There is no significant difference in the post geometry self-efficacy scores between students taught using the generative teaching strategy and those taught using conventional methods.

Table 2: Mann-Whitney U Test Results for Post-Instruction Self-Efficacy Scores by Teaching Strategy

Group	N	Mdn	IQR	U	p	Effect Size (r)	Decision
Experimental	52	14	3	5	0.001	0.86	Significant
Control	54	9	2				
Total	106						

Table 2 displays the results of the Mann-Whitney U test, which assessed the difference in post-instruction self-efficacy scores between the experimental and control groups. The results indicate a statistically significant difference in post-instruction self-efficacy scores between the two groups ($U = 5$, $p = .001$, $r = 0.86$). The experimental group (median = 14, IQR = 3) exhibited significantly higher self-efficacy scores compared to the control group (median = 9, IQR = 2). The large effect size ($r = 0.86$) suggests

that the generative teaching strategy has a substantial practical significance for students' self-efficacy. Therefore, the null hypothesis (H_{01}) that there is no significant difference in post self-efficacy scores is rejected.

Research Question Two: What is the difference in geometry self-regulation scores between students taught using the generative teaching strategy and those taught using conventional methods?

Table 3: Median Self-Regulation Scores Before and After Instruction by Teaching Strategy

Group	Pre_Self-regulation			Post_Self-regulation		Med Diff.	Remark
	N	Mdn	IQR	Mdn	IQR		
Experimental	52	11	3	17	2	6	Substantial improvement in self-regulation post-intervention.
Control	54	11	2.5	10	2	1	Minimal change in self-regulation post-intervention.
Total	106						

Table 3 details the median self-regulation scores before and after the intervention for both groups. Initially, both the experimental (N = 52) and control (N = 53) groups had comparable median self-regulation scores, with the experimental group scoring 11 (IQR = 3) and the control group scoring 11 (IQR = 2.5). Post-intervention, the experimental group showed a notable increase in median self-regulation to 17 (IQR = 2),

indicating a median difference of 6 and a median gain of 5. The control group's median self-regulation score, however, remained largely stable, shifting to 10 (IQR = 2) with a median difference of 1.

H₀₂: There is no significant difference in the post geometry self-regulation scores in geometry between students taught using the generative teaching strategy and those taught using conventional methods.

Table 4: Mann-Whitney U Test Results for Post-Instruction Self-Regulation Scores by Teaching Strategy

Group	N	Mdn	IQR	U	p	Effect Size (r)	Decision
Experimental	52	17	3	3	0.001	0.86	Significant
Control	54	10	2				
Total	106						

Table 4 presents the findings from the Mann-Whitney U test comparing post-instruction self-regulation scores between the generative teaching strategy group and the conventional methods group. A statistically significant difference was observed (U = 3, p = .001, r = 0.86). The experimental group (median = 17, IQR = 3) achieved considerably higher self-regulation scores post-intervention than the control group (median = 10, IQR = 2). The calculated effect size (r = 0.86) signifies a very large practical effect, suggesting that the generative teaching strategy had a substantial positive impact on students' self-regulation. Consequently, the null

hypothesis (H_{02}), asserting no significant difference in post self-regulation scores, is rejected.

Research Question Three: What is the difference between students' geometry self-efficacy and self-regulation scores when exposed to generative teaching strategy?

Table 5: Comparison of Median Self-Efficacy and Self-Regulation Scores Post-Instruction by Teaching Strategy

Group	Self-efficacy			Post_Self-regulation		Med. Diff.	Remark
	N	Mdn	IQR	Mdn	IQR		
Experimental	52	14	3	17	2	3	Self-regulation scores are notably higher than self-efficacy post-intervention.
Control	54	9	2	10	2	1	Both scores are low and closely aligned post-intervention.
Total	106						

Table 5 provides a comparison of median self-efficacy and self-regulation scores post-instruction for both teaching strategy groups. Within the experimental group ($N = 52$), post-intervention median self-efficacy was 14 ($IQR = 3$) and median self-regulation was 17 ($IQR = 2$). The median difference between these two constructs was 3, with a median gain of 2 for

self-regulation over self-efficacy. For the control group ($N = 53$), post-intervention median self-efficacy was 9 ($IQR = 2$) and median self-regulation was 10 ($IQR = 2$), showing a median difference of 1.

H₀₃: There is no significant difference between students' self-efficacy and self-regulation scores when exposed to generative teaching strategy.

Table 6: Wilcoxon Signed-Rank Test Comparing Post-Intervention Self-efficacy and Self-regulation Scores in the Experimental Group.

Comparison	N	Z	p	Effect Size (r)	Decision
Self-efficacy vs. Self-regulation	106	5.319	< .001	0.52	Significant

Table 6 presents the results of the Wilcoxon Signed-Rank Test, which was conducted to determine if there was a significant difference between students' post-intervention self-efficacy and self-regulation scores within the experimental group. The analysis revealed a statistically significant

difference between self-efficacy and self-regulation scores in the experimental group ($Z = 5.319$, $p < .001$, $r = 0.52$). The positive Z-value and medium effect size ($r = 0.52$) indicate that self-regulation scores were significantly higher than self-efficacy scores after exposure to the generative teaching strategy. This leads to the rejection of

the null hypothesis (H_{03}), suggesting a significant difference between these two constructs post-intervention in the experimental group.

Discussion

The Generative Teaching Strategy (GTS) significantly improved students' self-efficacy, shown by a notable rise within the GTS group, while the control group experienced a decline. This notable difference emphasises the strong positive effect of GTS, aligning closely with established self-efficacy theories (Bandura, 1997). This result resonates with past research, such as that by Fiorella and Kuhlmann (2020), which consistently highlights the beneficial impact of generative learning activities on student outcomes. Fiorella and Kuhlmann (2020) pointed out that involving students in retrieval practices and generative processes results in better long-term learning. Likewise, our findings suggest that GTS fosters greater student confidence in their geometry abilities, thereby boosting motivation in learning. Generative strategies, by encouraging students to actively build their understanding and engage in deeper cognitive processing (Fiorella and Mayer, 2015), offer more chances for mastery experiences and a stronger sense of achievement. In contrast, these outcomes differ markedly from some traditional methods, such as conventional lecture-based approaches, which have been shown to be less effective in fostering higher-order thinking and metacognitive skills. These methods often promote passive learning, which might hinder the development of self-efficacy and self-regulation, as indicated by research across various teaching and learning contexts. The differing results highlight

the vital need for a shift towards more interactive instructional approaches that enable students to actively engage with the learning content.

Several potential reasons may account for the observed differences in self-efficacy and learning outcomes between the generative teaching and conventional methods. Firstly, the interactive nature of the GTS encourages more active engagement, allowing students to construct knowledge collaboratively and meaningfully. This contrasts sharply with traditional rote learning strategies, where students may feel less invested in their learning experiences.

The improvement in self-regulation within the Generative Teaching Strategy (GTS) group shows how well it helps students guide their own learning, especially when the control group's scores stayed flat. This fits with studies indicating that methods encouraging active thought and awareness are key to building these skills (Robson et al., 2020). GTS's structured problem-solving also really helps students remember and grasp tough subjects like geometry (Robson et al., 2020). Teachers play a vital role here; as Liu et al. (2019) found, when teachers actively lead generative strategies, it truly boosts student motivation and results. So, tailored GTS lesson plans likely made a supportive learning space that helped students thrive (Liu et al., 2019). It's also clear that motivation, teaching styles, and self-regulation are connected, with a teacher's inspiring strategies deeply affecting student achievement and inner drive (Messer et al., 2025). This suggests that well-planned GTS not only improves how students manage their learning but also makes them more engaged and understanding,

even in tricky areas like geometry. Ultimately, the positive shifts seen with GTS highlight its power in growing students' self-regulatory skills, supporting the idea that active learning and engaged teaching are fundamental for student success (Zulkifli & Kutty, 2022). The finding that self-regulation scores were notably higher than self-efficacy scores within the GTS group post-intervention is particularly interesting. This suggests that while GTS powerfully enhances both constructs, it may exert a slightly stronger immediate impact on self-regulation. This could be attributed to the inherent nature of generative activities, which often explicitly require students to plan, monitor, and evaluate their learning processes, thereby directly fostering self-regulatory behaviours. While improved self-regulation can subsequently lead to increased self-efficacy through successful task completion, the direct engagement with self-regulatory processes within GTS might explain this observed difference. The implications of these findings resonate with the theoretical frameworks underpinning self-efficacy and self-regulation models. By enhancing students' self-efficacy through the GTS, students are likely to adopt a more proactive approach to their studies, fostering a greater sense of autonomy in their academic journey. This connection is supported by Cheng et al. (2023), who emphasise that generative strategies advance not only learning outcomes but also metacognitive awareness, thereby enabling students to better manage their learning processes. The significant improvement in self-regulation scores among the experimental group further suggests that self-efficacy and self-regulation are intertwined, reinforcing

the notion that self-efficacy is foundational for effective self-regulation in learning contexts.

Conclusion

Based on the objectives, research questions, and the tested hypotheses of this study, the following conclusions are drawn:

- i. The generative teaching strategy (GTS) has a statistically significant and substantial positive effect on students' geometry self-efficacy. Students taught with GTS demonstrated significantly higher self-efficacy scores compared to those taught with conventional methods. Therefore, the null hypothesis (H_{01}) stating no significant difference is rejected.
- ii. The generative teaching strategy (GTS) has a statistically significant and substantial positive effect on students' geometry self-regulation. Students in the GTS group exhibited significantly higher self-regulation scores than their counterparts in the conventional teaching group. Therefore, the null hypothesis (H_{02}) stating no significant difference is rejected.
- iii. For students exposed to the generative teaching strategy, there is a statistically significant difference between their self-efficacy and self-regulation scores, with self-regulation being notably higher. This indicates that while GTS enhances both constructs, its immediate impact may be more pronounced on students' abilities to plan, monitor, and regulate their learning. Therefore, the null hypothesis (H_{03}) stating no significant difference is rejected.

Thus, the generative teaching strategy is a highly effective instructional model for simultaneously boosting both the confidence (self-efficacy) and the self-directed learning skills (self-regulation) of students in geometry, with a

particularly strong effect on the latter. The study strongly recommends the integration of generative teaching strategies into the geometry curriculum to foster these essential psychological attributes for academic success.

Recommendations

Based on the findings of the study, the following recommendations are put forth for various stakeholders in education:

- i. Educators should adopt GTS in geometry curricula, supported by professional development, to boost student engagement, self-efficacy, and self-regulation.
- ii. Curriculum developers should update content to be more interactive and application-based, encouraging GTS and promoting self-regulated learning.
- iii. Policymakers must allocate funding and resources for ongoing teacher training in innovative strategies like GTS.
- iv. Policy initiatives should ensure all students have access to quality mathematics education and benefit from effective teaching strategies.

Suggestions for further studies

To build upon the current research and deepen the understanding of generative teaching strategies, the following areas are suggested for future investigation:

- i. Future research should examine the long-term impact of generative teaching strategies on students' self-efficacy and self-regulation through longitudinal studies.
- ii. Studies could assess the effectiveness of these strategies across diverse educational settings, considering cultural

influences on students' perceptions and behaviours.

- iii. Research in mathematics beyond geometry could test the generalizability of these strategies in promoting self-efficacy and self-regulated learning.
- iv. As education shifts online, exploring how generative strategies adapt to e-learning and affect student motivation and regulation is essential for digital curriculum development.

References

- Aboagye, K. O., Ke, Y. D., & Mante, D. A. (2021). Factors Influencing Students' Perceived Difficulties in Studying Geometry: A Case of Konogo-Odumasi, Ghana. *Open Journal of Social Sciences*, 09(09), 526–540. <https://doi.org/10.4236/jss.2021.99038>
- Adnan, N. A. S., & Osman, S. (2024). Innovative Augmented Reality Integration for Enhanced Geometry Education: A Review of the Impact on Student Interest, Self-Efficacy, and Academic Achievement. *International Journal of Academic Research in Progressive Education and Development*, 13(1). <https://doi.org/10.6007/ijarped/v13-i1/20782>
- Aldiabat, N. A. S., & Yew, W. T. (2024). Teaching Geometry Using Van Hiele's Phase-Based Instructional Strategy. *International Journal of Academic Research in Progressive Education and Development*, 13(1). <https://doi.org/10.6007/ijarped/v13-i1/20304>
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman.
- Bradley, R. L., Browne, B. L., & Kelley, H. M. (2017). Examining the influence of self-efficacy and



- self-regulation in online learning. *College Student Journal*, 51(4), 518–530.
- Cheng, M., Wang, F., & Mayer, R. E. (2023). Benefits of Asking Students to Make an Instructional Video of a Multimedia Lesson: Clarifying the Learning-by-teaching Hypothesis. *Journal of Computer Assisted Learning*, 39(5), 1636–1651. <https://doi.org/10.1111/jcal.12823>
- Fiorella, L., & Kuhlmann, S. (2020). Creating Drawings Enhances Learning by Teaching. *Journal of Educational Psychology*, 112(4), 811–822. <https://doi.org/10.1037/edu0000392>
- Fiorella, L., & Mayer, R. E. (2015). *Learning as a Generative Activity*. <https://doi.org/10.1017/cbo9781107707085>
- Gopalan, M., Rosinger, K. O., & Ahn, J. B. (2020). Use of Quasi-Experimental Research Designs in Education Research: Growth, Promise, and Challenges. *Review of Research in Education*, 44(1), 218–243. <https://doi.org/10.3102/0091732x20903302>
- Jablonski, S., & Ludwig, M. (2023). Teaching and Learning of Geometry—A Literature Review on Current Developments in Theory and Practice. *Education Sciences*, 13(7), 682. <https://doi.org/10.3390/educsci13070682>
- Jelatu, S., Sariyasa, S., & Ardana, I. M. (2018). Effect of GeoGebra-Aided REACT Strategy on Understanding of Geometry Concepts. *International Journal of Instruction*, 11(4), 325–336. <https://doi.org/10.12973/iji.2018.11421a>
- Juman, Z. A. M. S., Mathavan, M., Ambegedara, A. S., & Udagedara, I. G. (2022). Difficulties in Learning Geometry Component in Mathematics and Active-Based Learning Methods to Overcome the Difficulties. *Shanlax International Journal of Education*, 10(2), 41–58. <https://doi.org/10.34293/education.v10i2.4299>
- Liu, S. (2023). Motivational Strategies in Classroom of Second Language Teaching. 1, 489–493. <https://doi.org/10.36315/2023inpa110>
- Liu, W. C., Wang, J., Reeve, J., Kee, Y. H., & Chian, L. K. (2019). What Determines Teachers' Use of Motivational Strategies in the Classrooms? A Self-Determination Theory Perspective. *Journal of Education*, 200(3), 185–195. <https://doi.org/10.1177/0022057419881171>
- Machisi, E. (2021). Grade 11 Students' Reflections on Their Euclidean Geometry Learning Experiences. *Eurasia Journal of Mathematics Science and Technology Education*, 17(2), em1938. <https://doi.org/10.29333/ejmste/9672>
- Mata, L., Monteiro, V., & Peixoto, F. (2012). Attitudes Towards Mathematics: Effects of Individual, Motivational, and Social Support Factors. *Child Development Research*, 2012, 1–10. <https://doi.org/10.1155/2012/876028>
- Messer, E. J. E., Roome, H. E., & Legare, C. H. (2025). Learning to Control Through Culture: Explaining Variation in the Development of Self-Regulation. *Psychological Review*, 132(4), 956–972. <https://doi.org/10.1037/rev0000554>
- Mkenda, T. B. (2022). *Effective Classroom Practices for Unlocking Students' Potentials in Mathematics*. <https://doi.org/10.21203/rs.3.rs-1536613/v1>
- Robson, D. A., Allen, M. S., & Howard, S. J. (2020). Self-Regulation in Childhood as a Predictor of Future Outcomes: A Meta-Analytic Review. *Psychological Bulletin*, 146(4), 324–354.



<https://doi.org/10.1037/bul000027>

- Santos, L. M. D. (2022). The Learning Strategy of Third Language (L3) University Students for the Korean Language: A Study of Chinese Students. *International Journal of Instruction*, 15(3), 787–804. <https://doi.org/10.29333/iji.2022.15343a>
- Wang, Y. (2017). The Effectiveness of Integrating Teaching Strategies Into IRS Activities to Facilitate Learning. *Journal of Computer Assisted Learning*, 33(1), 35–50. <https://doi.org/10.1111/jcal.12164>
- Zetriuslita, Z., Nofriyandi, N., & Istikomah, E. (2020). The Effect of Geogebra-Assisted Direct Instruction on Students' Self-Efficacy and Self-Regulation. *Infinity Journal*, 9(1), 41. <https://doi.org/10.22460/infinity.v9i1.p41-48>
- Zulkifli, M. A., & Kutty, F. M. (2022). Relationship Between Specialization of Teaching Subject and Teaching Experiences with Teacher's Motivational Strategies. *Creative Education*, 13(10), 3238–3254. <https://doi.org/10.4236/ce.2022.1310207>