Students' Perceptions and Academic Outcomes in an Active Learning-Based Calculus I Course: Insights From Mediation Analysis

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Active learning can increase engagement, comprehension, and achievement in mathematics (Freeman et al., 2014; Fuchs & Sahmbi, 2024). Despite the widely reported benefits of active learning, students' perceptions remain mixed, with some studies noting resistance to these methods (Andrews et al., 2020; Finelli et al., 2018; Tharayil et al., 2018). This study investigates students' perceptions of the impact of active learning on their interest and enjoyment in mathematics and confidence in their mathematical abilities. Mediation analysis was used to explore whether students' perception of confidence mediates the relationships between interest in mathematics and academic achievement (grades) and interest and enjoyment. Research questions: (1) How do students perceive the impact of active learning sessions on their interest, enjoyment, and confidence in mathematics, and does this perception vary significantly depending on the teaching assistant? (2) Does confidence mediate the relationship between interest and academic outcomes (grades/enjoyment) in an active learning calculus environment?

Our analysis revealed that students' perception of the impact of active learning was positive overall. Specifically, out of the 142 students, over 40% of students reported an increase in their interest (65, 46%), enjoyment (63, 44%), and confidence (99, 70%) in mathematics after taking the calculus I course. Analysis of variance results indicated that teaching assistant (TA) was a significant factor for students' confidence, $F(3, 138)= 3.498$, $p = .017$, and enjoyment, $F(3, 138)=3.052$, $p = .031$, but not for students' interest, $F(3, 138)=2.571$, $p=.057$, at the .05 significance level. Correlation analysis shows the highest correlation (r=.86) between interest in mathematics and enjoyment in mathematics, moderate correlation (r =.60) between confidence in mathematics and the other two perception measures and weaker correlation (r=.37) between the course grade and the three perception measures. Mediation analysis was conducted to test the mediating role of confidence in the relationship between interest (independent variable) and grades and enjoyment as outcomes, respectively. Results showed that confidence partially mediates the effect of interest on grades, with a significant direct effect (b = .23, 95% CI [.05, .43], p =.02) and a significant indirect effect through confidence (b =.10, 95% CI [.01, .44], p =.04). Additionally, confidence significantly mediates the effect of interest on enjoyment, with both a significant direct effect (b = .84, CI [.74, .94], p < .01) and a significant indirect effect through confidence (b = .10, CI [.02, .18], p < .001). Pre-calculus experience, teaching assistant (TA), and small group participation score were control variables.

In line with prior research (e.g., Code et al., 2014), this study demonstrates that active learning positively impacts students' interest, enjoyment, and confidence in mathematics. Results also suggest that confidence is a crucial factor connecting interest to improved grades and enjoyment in addition to serving as a reliable predictor of success orientation and achievement (Kirikkanat & Soyer, 2018; Chue, 2020). Finally, although the TA was a significant factor on several student perception variables, further research is needed on the role of instructional support within active learning environments.

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References

Andrews, M. E., Graham, M., Prince, M., Borrego, M., Finelli, C. J., & Husman, J. (2020). Student resistance to active learning: do instructors (mostly) get it wrong? *Australasian Journal of Engineering Education*, 25(2), 142-154.

Chue, K. L. (2020). Effort, Enjoyment, and Self-confidence: A mediation model. *Journal of Cognitive Education and Psychology*, 19(1), 32-42.

Code, W., Piccolo, C., Kohler, D., & MacLean, M. (2014). Teaching methods comparison in a large calculus class. *ZDM-Mathematics Education*, 46, 589–601.

Ellis, J., Fosdick, B. K., & Rasmussen, C. (2016). Women 1.5 times more likely to leave STEM pipeline after calculus compared to men: Lack of mathematical confidence a potential culprit. *PloS ONE*, 11(7), e0157447. https://doi.org/10.1371/journal.pone.0157447

Finelli, C. J., Nguyen, K., DeMonbrun, M., Borrego, M., Prince, M., Husman, J., ... & Waters, C. K. (2018). Reducing student resistance to active learning: Strategies for instructors. *Journal of College Science Teaching*, 47(5).

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth,

M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *PNAS*, 111(23), 8410–8415.

Fuchs, S., & Sahmbi, G. (2024). Investigating the impact of active learning in large, coordinated calculus courses. *International Journal of Research in Undergraduate Mathematics Education*, 1-24. https://doi.org/10.1007/s40753-024-00234-6

Kirikkanat, B., & Soyer, M. K. (2018). A path analysis model pertinent to undergraduates' academic success: Examining academic confidence, psychological capital and academic coping factors. *European Journal of Educational Research*, 7(1), 133-150.

Kopparla, M. (2019). Experiences of Freshmen Enrolled in Math-Intensive STEM Majors (Doctoral dissertation, Texas A&M University).

Laursen, S. L., Hassi, M.-L., Kogan, M., & Weston, T. J. (2014). Benefits for women and men of inquiry-based learning in college mathematics: a multi-institution study. *Journal for Research in Mathematics Education*, 45(4), 406–418.

Lenz, L. (2015). Active learning in a math for liberal arts classroom. Primus, 25(3), 279–296. Maciejewski, W. (2016). Flipping the calculus classroom: An evaluative study. *Teaching Mathematics and Its Applications*, 35, 187–201.

Roop, J. P., Edoh, K., & Kurepa, A. (2018). Instructional Selection of Active Learning and Traditional Courses Increases Student Achievement in College Mathematics. *Journal of Education and Learning*, 7(5), 11-19.

Tharayil, S., Borrego, M., Prince, M., Nguyen, K. A., Shekhar, P., Finelli, C. J., & Waters, C. (2018). Strategies to mitigate student resistance to active learning. *International Journal of STEM Education*, 5(1), 1-16.