Original Research Paper

Academically Improved Students due to Peer Instruction and Classroom Engagement

Nadira Ghattas[1], Erica Harvey[2]

[1]*Secondary Science, West Virginia Academy, Morgantown, WV, USA;*
[2]*Department of Chemistry, Professor Emerita, Fairmont State University, Fairmont, WV, USA.*

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**Corresponding Author*: Nadira Ghattas, West Virginia Academy, Morgantown, WV, USA;
Email: nadirag7@gmail.com

Abstract: Active student engagement in classrooms and peer instruction are examples of techniques that have been reported to enhance students' academic performance, peer communication, and sense of belonging in classrooms. This paper examines college students' experience with peer teaching in a first-year chemistry class that used a flipped-classroom approach. Students self-selected into groups with 2-5 members each, and the groups signed up on a rotating basis to present and teach their peers different topics throughout the semester. Peer instruction was conducted under the supervision and in the presence of the course instructors. Students filled out a survey after every class meeting to evaluate the presenting group and the level of understanding of the presented material. Survey results highlight valuable effects of peer instruction; students reported that peer-teaching presentations helped them improve in areas related to their academic performance (26%), academic understanding (23%), self-confidence (23%), STEM interest and persistence (~7%), and most especially their communication skills with their peers in their assigned groups (78%). The results of this study have implications for educators who wish to enhance students' engagement and academic performance in classrooms.

Keywords: Peer teaching; peer instruction; self-confidence; academic performance; peer communication.

Introduction

Teachers and instructors bear not only the role of delivering content knowledge, but also of facilitating a holistic learning environment that serves students beyond their academic performance; an environment that promotes self-esteem and self-efficacy, peer communication, positive attitudes, interest in learning the subject matter, and other factors that support a strong retention rate. One of the methods that can be employed in this holistic setting is peer instruction; a non-traditional teaching approach where students are actively involved and collaboratively engaged in activities that promote the learning process (Hayden et al., 2021).

Peer instruction is a pedagogical approach rooted in social constructivism, a theory developed by psychologist Lev Vygotsky in 1968. He proposed that learning and knowledge construction can be built and occur through social interaction, which is necessary for lifelong personality development and cognitive growth. Social constructivism supports peer instruction as a pedagogical method that promotes active involvement and collaboration between and among learners to help them learn, understand, and retain knowledge during their teaching/learning experience via social communication and shared experience (Anna, Huma, & Farah, 2021). The use of peer instruction can be traced at least as far back as the ancient Greeks (Topping, 1996; Topping, 2015). According to Öz (2024), exchanges of knowledge among groups of students played a key role in spreading ancient philosophical ideas. Likewise, during periods when mixed-age classes were common, peer instruction served as a primary method of teaching (pp. 505–506).

Peer instruction includes peer teaching and peer tutoring, both of which involve working with peers in a cooperative manner (Cockerill, Craig, & Thurston, 2018). Peer teaching and peer tutoring may differ in

terms of the involvement of more experienced students (e.g., such as students who have previously taken the class in which they are helping peers). Peer tutoring consists of more experienced students tutoring or helping less experienced students (Bagum et al., 2022). Peer teaching occurs when students are taking a class together at the same time and learning from one another. The distinction is subtle and the benefits from the two techniques are closely interrelated, especially when students taking a course together are tasked with becoming "experts" on specified subject matter so that they can teach their peers.

Like peer teaching, peer tutoring promotes a collaborative learning environment and fosters a sense of teamwork among students as they are learning from each other. Gongden (2021, p.101) describes peer tutoring as a "cognitive apprentice between an expert and a novice." Topping (2015) defines peer tutoring as a strategy for the acquisition of knowledge and skills where individuals from similar social groups help each other learn. "Peer tutoring is done in pairs or small groups that assume an asymmetric relationship by adopting a role of tutor for one of the students whose role is guiding, and another one who is tutored; both work on a common goal; where also dominates a dynamic of interaction regulated and accompanied by the teacher" (Flores, 2018, p.954).

Peer teaching provides students with an opportunity to interact in classrooms where they can teach and learn from each other, and share knowledge, skills, etc. In peer teaching, students play an active role that is enjoyed only by their teachers in traditional class formats. Peer teaching engages students in a learning environment that leads to deepening their understanding and improving their learning through teaching their peers, therefore leading to improving their grades (Roy and Swargiary, 2024; Rusli et al., 2021; Öz, 2024; Freeman et al., 2014). Whitman (1988) states that, "to teach is to learn twice." It is "Learning by teaching" (Topping, 1996). Students gain better understanding as they act in the role of a teacher and prepare for the topics to be taught to their peers. Peer teaching enables students to learn from each other and views them as active learners rather than passive recipients of knowledge (Goldschmid & Goldschmid, 1976).

The significance of peer instruction has been investigated in studies that integrated its use at different educational levels and in a range of subject areas, including economics, medicine, physical education, science, technology, engineering and mathematics (STEM), reading, and applied sports science. There has been an increasing focus on exploring impacts at the cognitive (academic performance and metacognition) and affective (attitudes) levels at low delivery cost (Cockerill, Craig, & Thurston, 2018; Cohen et al., 1982; Olulowo et al., 2020; Flores, 2018; Topping, 2015).

The study of Olulowo et al. (2020) reflects upon the use of peer teaching as an effective strategy that enhances students' academic performance, communication skills, and enthusiasm for learning more than the conventional/traditional lecture strategy. Aftab, Tehsain, & Bagum (2022) reported similar results of the effectiveness of peer tutoring on the performance of chemistry students. They consider peer tutoring as a powerful source of change of behavior of learners. In addition to the abstract nature of chemical concepts, Gongden (2021) pointed out that poor student achievement in chemistry was due to the poor teaching methods often used by chemistry teachers. Gongden's investigation revealed that students who participated in peer tutoring activities demonstrated significantly higher achievement and retention of knowledge than those exposed to conventional teaching (Gongden, 2021). In line with Gongden's favorable results of peer instruction, Alegre et al. (2018), Moliner & Alegre (2020), and Gan & Hong (2010) findings show that students achieved higher math scores compared to those receiving traditional instruction. They also reported that the peer tutoring groups showed higher interest in learning mathematics and higher mathematics self-efficacy.

Similar results were found in biology classrooms. Ullah, Tabassum, and Kaleem (2018) reported that peer teaching had a significant impact on the academic achievement of students in biology. Similarly, Jibrin & Zayum's quasi-experimental design study in biology (2012) reported that students taught using peer tutoring achieved better results than those taught using lecture methods.

Multiple studies demonstrate the effectiveness of peer instruction at enhancing learning and academic achievement (Hidayat and Saad, 2025; Gongden, 2021; Alegre et al., 2018; Moliner & Alegre, 2020; Gan & Hong, 2010; Aftab, Tehsain, & Bagum, 2022; Olulowo et al., 2020; Cockerill, Craig, & Thurston, 2018; Cohen et al., 1982; Flores, 2018; Topping, 2015; Comfort & McMahon, 2014).

Other researchers have investigated the significance of peer instruction on aspects beyond academic achievement. Ain et al. (2023) indicated that peer tutoring has achieved good cognitive and affective

outcomes since the 1990s. The meta-analysis of Hidayat and Saad (2025) revealed the benefits of peer teaching on the development of other skills and affective outcomes (such as self-concept, critical thinking, intrinsic motivation, and attitudes), placing an emphasis on STEM disciplines. Due to the nature of cooperation that takes place in peer teaching, it promotes acquisition of knowledge, understanding, and other skills. It benefits both student (tutor) and student (tutee) (Cohen et al., 1982; Goldschmid & Goldschmid, 1976; Comfort & McMahon, 2014).

Additionally, classes that employ peer instruction reported it as a critical strategy with a substantial impact on increasing students' persistence in science, technology, engineering, and mathematics (STEM) disciplines and ultimately the number of students who receive degrees in STEM (Freeman et al., 2014; Watkins and Mazur, 2013; Olson & Riordan, 2012). This is imperative to The President's Council of Advisors on Science and Technology's call for an increased number of students who graduate from the STEM field (Olson & Riordan, 2012). The highlighted educational and social benefits of peer teaching as a valuable strategy in academic settings align with this call. The Council emphasized the need to solve the pipeline problem and meet the economic projection in the U.S. where millions of STEM professionals are needed in the workforce (Olson et al., 2012). In order for the U.S to retain its prominence in science and technology, the "Engage to Excel" report indicates that students must be engaged to excel in STEM fields due to its importance in life and for the development of society (Olson et al., 2012).

Materials and Methods

Participants

Subjects of this study represent the 48 students who were enrolled in Foundational Biochemistry (CHEM 2200, the second semester introductory course for science majors) at Fairmont State University throughout the spring semester in 2022. Two instructors taught three sections of the course, all of which utilized a peer-teaching technique. Two peer mentors supported students in the course and helped with the design and implementation of the peer-teaching strategy. The project reported on in this paper was a First2 Network-supported test of change that was implemented and documented through a Plan-Do-Study-Act (PDSA) cycle with coaching and support from the Network and Institutional Review Board (IRB) approval through Fairmont State. First2 Network (https://first2network.org) is a two-state initiative with the aim of improving success and retention of rural, first-generation and low-income STEM majors.

Materials

Three distinct peer-teaching surveys were developed for this study. Prior to starting use of these surveys, they were reviewed by First2 improvement science coaches and also by students (both peer mentors and enrolled students) for clarity and to eliminate ambiguity. Peer-teaching surveys (internal and external) were utilized throughout the semester. The peer-teaching internal survey was utilized by group members in the presenting group to evaluate one another's efforts, contributions, strengths, and areas for improvement. This was important so that a single strong student would not take over the work for the entire group. The external peer-teaching survey was used by the rest of the class (who were not members of the presenting group for that day) to evaluate the presenting group. At the end of each class session, students were prompted to complete the survey on the spot. There were a few times when students were asked to complete the surveys outside of the classroom due to lack of time in the classroom. They were reminded to complete the surveys via Remind messaging software. The third survey was an overall Peer-Teaching Satisfaction Survey (PTSS), shared with all CHEM 2200 students at the end of the semester. Only students who were enrolled in the course had access to the survey links. Survey responses were not anonymous. Curse instructors had access to data linking students to their responses, but identifiable information was not shared and individuals outside of the course had no access to the surveys or their responses.

Study Design and Implementation

The peer-teaching presentation technique was implemented throughout the Spring semester (2022) in CHEM 2200 at Fairmont State University and under the supervision and presence of CHEM 2200 instructors. Early in the semester, students self-selected into formal groups of 2-5 members each. CHEM 2200 used a flipped classroom technique where supportive readings, videos and repeatable "check your preparation" quizzes were posted in Blackboard. The quiz for a particular day's material was due prior to 9 a.m. so all students

had an incentive to engage ahead of time with the material to be presented during the peer teaching. The faculty members for CHEM 2200 used a Google Calendar to post the pre- and post-class work for the assigned topic of the day and made it visible to all students.

At the beginning of the semester, each group in a given section signed up for the order in which they would present. After that first set of presentations, groups alternated in presenting almost every class meeting. The alternating groups were shared with students, so they knew well ahead of time when their group was presenting. Pre-assigned peer-teaching problems were created by instructors and posted on Blackboard, associated with the corresponding learning outcomes for the topic of the day. Presenting groups usually worked on the assigned problems as a whole group and were able to reach out to faculty members and even the tutoring center, if help was needed. Within the group itself, there was a lead-presenter with the responsibility of presenting detailed work for the assigned problems or even the blackboard quizzes. Lead presenters would rotate within the group for every peer-teaching presentation done by the group, so that each student was able to be the lead-presenter at least once during the term. Solutions to assigned peer-teaching problems (from instructors and/or presenting groups) would be posted in Blackboard after the peer presentations were completed for all three CHEM 2200 sections.

No specific format was required for the presenting group to use when presenting, but students were encouraged to share their own notes from the videos/reading with their peers, to use technology (e.g. using document camera, PDF, tablets, etc.), and to actively engage all other groups in the discussion. Presenting groups were allowed to use the whiteboard in the classroom, as well. Adaptations from the Covid-19 pandemic were still in place, so sessions were offered in a hybrid format to support students who needed to be at home due to illness.

The peer-teaching presentation component accounted for 3 points (3%) of the overall course grade. All lead-presenters received 1 point (1%) for presenting throughout the semester. Completion of the internal or external surveys for each class session was also incentivized. Completers who filled out the peer-teaching presentation survey utilizing the external link were credited 1 point (equivalent to 1% course grade), if they filled out the survey at least 50% of 33 (number of peer-teaching presentation sessions). The third percentage point reflected the actual points/percent (up to 1%) results for the members' contribution to the team, measured with the internal peer-teaching presentation survey results.

Towards the end of the Spring 2022 semester, students in CHEM 2200 were asked to complete the overall PTSS. Completion of this survey was incentivized in two ways. First, completers were offered a silly mistake (SM) credit that they could trade in to get full credit (2 course percentage points) for a mastery-based assessment of a learning outcome on an exam, assuming they had just made a "silly mistake" on the question or problems that made up that mastery assessment. (Without the trade-in credit, students who made a silly mistake would earn only half-credit, 1 course percentage point, on the assessment for that learning outcome.) Second, for students who ended the term on the borderline between two grades, PTSS completion was used as a deciding factor for instructors to assign the higher of the two grades.

Results

The results reported here are based on a small-scale study group (48 total students enrolled in 3 sections of CHEM 2200 in Spring 2022) with a high (89.6%) response rate. Only 1 of the 43 respondents reported ever previously being in a classroom that utilized peer teaching. Based on the results of one of the PTSS questions, "*In what area(s) did peer-presentations improve you on?*" students indicated that peer-teaching presentations helped them improve in areas related to their academic performance (26%), academic understanding (23%), self-confidence (23%), STEM interest and persistence (~7%), and most especially their communication skills with peers in their assigned groups (78%). The summary is presented in Figure 1.

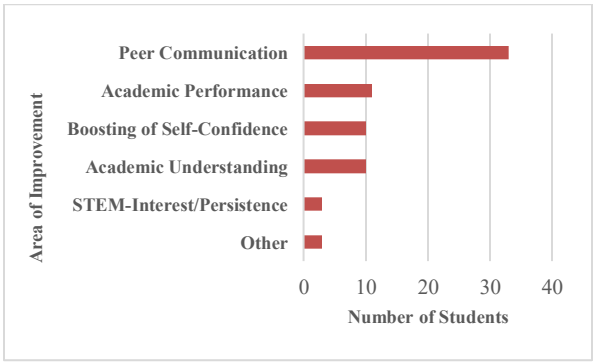

Figure 1. Areas of improvement due to peer teaching. This bar graph illustrates the areas in which students felt they improved as a result of participating in peer teaching.

Academic performance improved following the peer teaching as evidenced by higher earned grades in CHEM 2200 for Spring 2022 compared to Spring 2019. Students across these years were assigned identical or equivalent assignments and examinations covering the same material. Comparing the study year's group (2022) with the nearest pre-COVID year (2019), our data show that the implementation of peer-teaching presentations resulted in many fewer "D" grades, with a concomitant increase in students earning "B" and "C" grades. The percentage of A and F grades were identical in 2019 and 2022, but 10% more students earned B grades in 2022, 2% more students earned C grades in 2022 and the number of D grades decreased by more than half in 2022 compared to 2019. It is worth emphasizing that overall student achievement was higher in 2022, using peer teaching, than it was in 2019, when an alternative teaching approach was used that involved instructor lecture combined with active learning activities in small groups. Table 1 below summarizes the comparison.

Table 1. Overall CHEM 2200 course grades comparisons.

	Students (N=48) Yr.		Students (N=48) Yr.	
Grade	2022	% Grade 2022	2019	% Grade 2019
A	14	29.2	14	29.2
B	15	31.3	10	20.8
C	10	20.8	9	18.8
D	4	8.3	10	20.8
F	5	10.4	5	10.4

Although the collected data indicates positive impacts on a variety of favorable factors, such as academic performance and understanding, peer communication, and boosting self-confidence, the final questions on the overall peer-teaching satisfaction survey yielded unexpected results. About 60% of respondents responded "no" when asked if they would recommend that instructors continue using peer teaching with future students, 33% said maybe, and only about 7% fully endorsed the idea. Open-ended responses to the questions "What are some of the peer-teaching challenges or obstacles, if any, that you have encountered when trying to prepare for the peer-teaching presentation?" and "How can peer-teaching presentations be improved?" provided a variety of reasons for their opinion. Figure 2 below depicts the results.

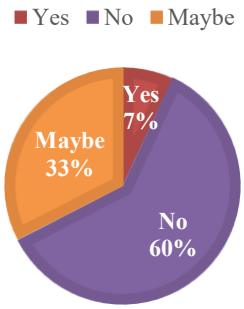

Figure 2. Recommendation for continued future use of peer teaching. This pie chart reflects the recommendation for continued use of the peer-teaching technique with future groups of students.

Limitations of this study include the fact that the survey instruments were not tested for validity and reliability. Also, having survey completion contribute to course grades might have affected student responses to the survey questions. Modest changes in course content (and changes to student expectations and preparedness as a result of the Covid-19 pandemic disruptions) may have impacted grade comparisons between 2019 and 2022, though the likely impact of the changes would have been to expect lower grades in 2022, all other things being equal. According to Topping (1996), peer teaching involves more able students supporting less able students in cooperative or small-group settings. In the present study, chemistry students were given the freedom to select their own group members. As a result, some groups faced greater challenges due to a lack of internal expertise. This suggests that group formation should be carefully managed by instructors. In other words, more able students should be paired with those who have learning difficulties or with peers who have less experience.

Discussion

This study was designed to investigate college students' experience with peer instruction in small-sized introductory chemistry classrooms. Active learning and peer teaching are reported to have positive impacts on students' academic performance and benefit students in all sizes of classrooms. Results of the current study are consistent with the 2014 analysis by Freeman et al., which reported that active learning had a statistically significant positive effect on small (defined as <50), medium, and large classrooms, with significant variation noted for small class sizes. Improved academic performance associated with peer instruction is also aligned with numerous studies and findings

conducted by other researchers in mathematics, biology, and chemistry classrooms. (Hidayat and Saad 2025; Gongden, 2021; Moliner et.al.,2018; Moliner & Alegre, 2020;; Gan & Hong, 2010; Aftab, Tehsain, & Bagum, 2022; Olulowo et al., 2020; Cockerill, Craig, &Thurston, 2018; Cohen et. al., 1982; Flores 2018; Topping 2015; Comfort & McMahon 2014).

In the current study, a general conclusion can be drawn that overall student academic achievement was higher under peer-instruction learning, as evidenced by the change in final grade distribution and student self-reports. Based on classroom observations, selected open-ended survey responses, and informal conversations with students, the instructors hypothesized that this was likely due to the effort that was put forth by students in attempting to conceptualize and deepen their understanding of the material and in articulating their understanding to their peers. This by itself helps in the process of comprehension and retention of the information and applying it on quizzes, tests, and exams. Comparing final course grades is a reasonable approach because students took identical or equivalent quizzes and tests in CHEM 2200 across different years and the small portion of the course grade contributed by the peer-teaching components was similar to the portion previously contributed by other group work components.

Peer teaching also played a big role in enhancing students' social and emotional skills by promoting a sense of collaboration and peer communication as a team for nearly 80% of students and boosting the level of self-confidence and decreasing the anxiety level for about a quarter of students. Despite these major benefits, the overall satisfaction survey results show an unfavorable student attitude towards the continued use of the peer-teaching technique with future students. Open-ended responses documented in response to the PTSS question, "*What are some of the peer-teaching challenges or obstacles, if any, that you have encountered when trying to prepare for the peer-teaching presentation?*" indicate that this may be due to the difficulty level of the topics that were assigned for peer presentation in CHEM 2200. The assigned topics were too challenging for some students, who reported the stress associated with giving the presentations. One student stated "If I did not understand the material, I found it very challenging to try to teach it to the class. I also found it hard to communicate some concepts that I understood but did not know how to explain." Another added, "If you didn't fully understand the concept being taught, it was sometimes challenging to do the assigned peer-teaching work and teach it." Yet, another student shared that "peer teaching is a good implication. However, I think that peer teaching should only be used in the easier [learning] outcomes. As the outcomes got more challenging the teaching became less effective for the students who were not presenting." The preparation time outside of the classroom was another factor that contributed to the recommendation to discontinue usage of the peer-teaching technique with future groups of students. Furthermore, this was the first time for all but one of the students to experience the peer-teaching technique as part of a class. This added an unfamiliar layer of responsibility and accountability for students to present and teach to their peers. Notably, the only student who reported having previous experience with peer teaching was one of the three students who said yes to continuing the technique going forward.

Student responses to the open-ended questions on the PTSS and literature sources align to provide helpful suggested modifications for instructors going forward. Revisiting the peer-teaching methodology and introducing it first with basic concepts and simpler topics would support students better than starting it immediately with more complex topics, textbook readings or long presentations (Öz, 2024). The combination of responsibility and the process of knowledge acquisition of complex topics were key factors for CHEM 2200 students not to recommend the use of the peer-teaching technique with future students. Implications of this study and previous studies, in terms of increased academic success with peer teaching, raise concerns about the continued use of instructor-based or traditional lecturing approaches that do not require as much active student participation. However, the adoption of effective new techniques such as peer instruction that are not familiar to students may be best done gradually to increase student buy-in and satisfaction, and to give students time to reflect on the relationship between their ways of engaging with challenging material and the effect on their academic success.

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Literature Cited

Aftab, M. J., Tehsain, M. J., & Bagum, M. (2022). Effect of Peer Tutoring on Students' Academic Performance in Chemistry at Secondary Level. VFAST Transactions on Education and Social Sciences, 10(3), 55-64.

Alegre F.,Miravet L., Maroto A., Valentín G. (2020). Academic achievement and peer tutoring in mathematics: a comparison between primary and secondary education. Sage Open, 10 (2). Article 215824402092929, 10.1177/2158244020929295

Alegre, F., Moliner, L., Margoto, A., & Lorenzo-Valentin, G. (2018). Peer tutoring in mathematics in primary education: a systematic review. Educational Review, 7(16), 767-791. https://doi.org/10.1080/00131911.2018.1474176

Bagum, M., Tehsain, M. J., Jamil, S., Ahmad, N., Aftab, M. J., & Islam, A. (2022). Comparative analysis of peer tutoring and conventional strategies in students' performance in chemistry. Al-Qantara, 8(4), 134-156.

Cockerill M, Craig N, Thurston A. (2018). Teacher Perceptions of the Impact of Peer Learning in their Classrooms: Using Social Interdependence Theory as a Model for Data Analysis and Presentation. International Journal of Education and Practice. 6(1):14–27. https://doi.org/10.18488/journal.61.2018. 61.14.27

Cohen, P.A., J.A. Kulik and C.L.C. Kulik, (1982). Educational outcomes of tutoring: A meta-analysis of findings. American Educational Research Journal, 19(2): 237-248.

Comfort, P.; McMahon, J.J. (2014). The effect of peer tutoring on academic achievement. J. Appl. Res. High. Educ., 6, 168–175.

G. Flores, D. Ibeth, U. Ibarra et al. (2018) "Peer tutoring as an improvement strategy for school exploitation," European Journal of Educational Research, vol. 7, no. 4, pp. 953–961.

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. Proceedings of the National Academy of Sciences, 111(23), 8410–8415. https://www.pnas.org/doi/10.1073/pnas.1319030111

Goldschmid, B., Goldschmid, M.L. (1976). Peer teaching in higher education: A review. High Educ 5, 9-33. https://doi.org/10.1007/BF01677204

Gan, S., Hong K. (2010) . The effectiveness of peer tutoring in the teaching of mathematics. Malaysian Journal of Learning and Instruction, 7. DOI:10.32890/mjli.7.2010.7622

Hayden, Cindy L.; Carrico, Cheryl; Ginn, Cassandra Catherine; Felber, Alexis; and Smith, Shelby, "Social Constructivism in Learning: Peer Teaching & Learning" (2021). Pedagogicon Conference Proceedings. 7. https://encompass.eku.edu/pedagogicon/2020/learningpartners/7

Hidayat, R., & Saad, M. R. M. (2025). A Meta-analysis of the effect of peer tutoring in Science, Technology, Engineering and Mathematics (STEM) subjects. International Journal of Educational Research Open, 8.

Jibrin, A. G.; Zayum S. D.Effects of peer tutoring instructional method on the academic achievement in biology among secondary school students in Zaria Metropolis, Nigeria. Journal of Research in Education and Society. 3(2), 14-18.

Miller, D., Topping, K., & Thurston, A. (2010). Peer tutoring in reading: The effects of role and organization on two dimensions of self-esteem. British Journal of Educational Psychology, 80(3), 417–433. https://doi.org/10.1348/000709909X481652

Moliner L., Alegre F. (2020). Effects of peer tutoring on middle school students' mathematics self-concepts. PLoS ONE 15(4): e0231410.https:// doi.org/10.1371/journal.pone.0231410.

Olulowo, T., Igo, O., and Ugwoke, E., (2020). Using Peer Tutoring to Improve Students' Academic Achievement in Financial Accounting Concepts. Education Research International (12):1-10. DOI:10.1155/2020/8871235

Olson, S., & Riordan, D. G. (2012). Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics.

Report to the President. Executive Office of the President. Retrieved from https://files.eric.ed.gov/fulltext/ED541511.pdf

Öz, E. (2024). Effects of peer instruction on academic achievement: a meta-analysis Pedagogies: An International Journal,19(4),505–522. https://doi.org/10.1080/1554480X.2023.2246447

Qurat ul Ain * , Allen Thurston, Alison MacKenzie, Canan Ozkaya. (2023). What does previous research tell us about the effects of peer tutoring on metacognition in primary and secondary schools? International Journal of Educational Research Open, 4.

Roy K. and Swargiary, K. 2024.Effectiveness of peer teaching in enhancing academic performance, engagement, and social-emotional outcomes among high school students: A Quasi-experimental study. Researchgate. DOI:10.13140/RG.2.2.28650.32965

Rusli, M., Degeng, I., Setyosari, P., and Sulton. 2021 Peer teaching: Students teaching students to increase academic performance. Teach Theol Relig. 24:17-27 https://doi.org/101111/teth.12549

Saleem, Anna., Kausar, Huma., and Deeba, Farah. (2021). Social Constructivism: A New Paradigm in Teaching and Learning Environment. Perennial Journal of History. 2(2):403-421. DOI:10.52700/pjh.v2i2.86

Topping, K.J., (1987). Peer tutored paired reading: Outcome data from ten projects. Educational Psychology, 7(2): 133-145.

Topping, K.J. (1996). The effectiveness of peer tutoring in further and higher education: A typology and review of the literature. High Educ 32, 321–345. https://doi.org/10.1007/BF00138870

Topping, Keith. (2015). Peer tutoring: old method, new developments. Journal for the study of education and

development.
38(1).https://doi.org/10.1080/02103702.2014.996407

Ullah I, Tabassum R, Kaleem M. (2018). Effects of Peer Tutoring on the Academic Achievement of Students in the Subject of Biology at Secondary Level. Education Sciences. 8(3):112. https://doi.org/10. 3390/educsci8030112

Watkins, J., & Mazur, E. (2013). Retaining Students in Science, Technology, Engineering, and Mathematics (STEM) Majors. Journal of College Science Teaching, 42(5), 36–41. https://doi.org/10.2505/4/jcst13_042_05_36

Whitman, N.1988. Teaching: To Teach is To Learn Twice By ASHE-ERIC Higher Education Report No. 4.