Technology-Mediated Peer Learning Environments

Soren Rosier, Stanford University, rosier@stanford.edu
Ojas Karnavat, Monta Vista High School, omkarnavat@gmail.com

Abstract: This paper reports on our five-month design based research study with a middle school in India, building a peer learning ecosystem from the ground up. With technology organizing every aspect of implementation, we gained valuable insights on the critical roles for technology in training effective peer helpers and optimally matching tutoring pairs. We also extracted best practices for establishing a community of co-learners and promoting the motivational elements that students most value.

Peer tutoring in classrooms is a more feasible and scalable learning arrangement than tutoring by teachers and professional tutors. It increases learning for tutees *and* tutors (Bowman-Perrott et al., 2013; Leung, 2015; Kobayashi, 2019), but is rarely implemented. The key barriers include challenges in implementation, promoting positive interdependence, and student collaboration skills. During a five-month design based research study with two Indian middle school classes, we studied the affordances of technology for overcoming these implementation challenges of efficiently matching, organizing, and assessing pupils in math classrooms built around peer tutoring.

Challenges in implementation. Despite being widely viewed as a valuable pedagogical framework by scholars and educators alike, it is estimated that only 7% of elementary school class time in the US is spent on group work (Pianta et al., 2007). Survey data suggests the main challenges teachers perceive are managing time, organizing peer interactions, aligning with required curricula, and assessing pupils (Buchs et al., 2017). Each implementation feature demands significant time from teachers whose time is already short.

Challenges promoting positive interdependence. When describing challenges of group learning in their classrooms, teachers often mention interactional dynamics between students. Teachers worry some students may "slack off" or become "passengers" (Johnson & Johnson, 2006), while others may not care to help peers. These are common issues when activities are not structured to promote positive interdependence—a sense of shared goals—which is critical to successful cooperation.

Challenges with student collaboration skills. Left to their own untrained devices, student discourse is often unproductive and can even be detrimental. Webb and Mastergeorge (2003) found that overly didactic behaviors predict lower understanding by "helped" students than no interaction at all. Without intervention, helping-students tend to provide shallow explanations and questions (Roscoe & Chi, 2007; Topping, 2005), perform most of the explaining (King, 1997), and fail to monitor and respond to peers' understanding (Roscoe & Chi, 2007).

Technological solutions

Training. The first phase of this design based research study was naturalistic peer tutoring during math class for three weeks. In week four, every student was trained through the PeerTeach web application to reorient their teaching mindsets to incorporate evidence-based strategies. This 40-minute training focuses on transitioning students from didactic explainers to savvy questioners capable of promoting active, student-centered learning.

The training has three parts. First, students watch short intro videos describing three of the most important and under-utilized teaching moves—eliciting, revoicing, and probing (Chapin & Anderson, 2013)—while typing notes. Second, students engage in a noticing activity by tagging a video of a tutoring interaction to attune their eyes to these high-leverage teaching moves. And third, students do a simulation exercise teaching a virtual character by choosing the best utterance among presented options, receiving feedback on their decisions in the form of responses from the learner and seeing the "learn-o-meter" move up or down based on whether it is learning. The training is largely influenced by Sherin's (2005) noticing framework, which asserts that teachers must attend to important teaching moments, relate them to useful pedagogical frameworks, and act based on pedagogically-sound reasoning.

Optimized Matching. To match students, math pre-assessment data was used to identify students with specific areas of need and pair them with peer tutors who had mastered those topics. To enact this, we developed a reward function for evaluating the quality of tutor-tutee-topic matches that increased with higher tutor mastery, lower tutee mastery, and more balanced role-taking for students. The output was an optimized set of tutor-tutee-topic across a class of students with the greatest total reward. In week seven, we augmented our matching formula to additionally emphasize student compatibility. To execute this more complex system for matching optimization, we asked students how well they work with each peer then included their reported compatibility in the reward function.

Summary Insights

Several indicators confirmed the efficacy of this technology-mediated training and matching system in creating productive and meaningful learning experiences. Five-question pre-assessments preceded 208 20-minute peer tutoring sessions, followed by equally challenging five-question post-assessments. Tutored students grew from 38% proficiency to 65%, on average. This constituted a large effect size (Cohen's d = 1.20). Beyond measured learning gains, 20-70 minute interviews with 12 focal students at the beginning, middle, and end of the study yielded compelling revelations on how students thought about themselves, school, and peer learning.

Positive interdependence. In this study, the responsibility of helping others learn engendered a powerful sense of duty—what Chase et al. (2009) dub the *protege effect*. For students being tutored, there was a strong sense of gratitude, particularly for the personalized attention afforded by one-on-one interactions. Focal students consistently described this peer learning experience as providing more attention than they ever receive in the classroom, allowing for more question-asking, and mitigating the fear of asking questions. Tutoring pairs also expressed a clear sense of shared purpose, where success depended on both students executing their individual roles sufficiently, in pursuit of a common goal. Predicting compatible pairings between students further increased comfort and risk-taking without any declines in measured learning.

Student collaboration skills. The game-based PeerTeach training modules laid the foundation for effective helping during this design-based research study. The training had clear take-up for critical pedagogical moves, successfully shifting students from overly didactic teaching to student-centered learning. Beyond specific skills, the training also promoted a sense of confidence, making experiences more gratifying. With few existing digital tools for training effective interactional behavior, the frontiers are open for technologists and learning scientists to develop increasingly responsive training systems.

A final note. Studies show that effective school-based tutoring 1) typically occurs often and consistently, 2) ideally happens during the school day with active classroom integration, and 3) harnesses data for tailored instruction (Nickow, Oreopoulos, & Quan, 2020; Robinson et al., 2021). Each factor allows tutors to build on classroom experiences to reinforce relevant, timely skills. But school-based tutoring via adult professionals creates enormous expense and logistical challenge, and precludes valuable learning opportunities that emerge when students teach. This study offers proof of concept that teachers can facilitate peer tutoring in their own classrooms when technology supports the complex processes of training, assessing, matching, and facilitating sessions.

References

Bowman-Perrott, L., Davis, H., Vannest, K., Williams, L., Parker, R., & Greenwood, C. (2013, March). Academic benefits of peer tutoring: A meta-analytic review of single-case research. *School Psychology Review*.

Buchs, C. & Volpé, Y. (2015). *How elementary teachers implement cooperative learning after a short training*. International Association for the Study of Cooperation in Education, Odense Denmark, October 2015.

Chapin, S. H., & Anderson, N. C. (2013). *Classroom discussions in math: A teacher's guide for using talk moves to support the Common Core and more*. Math Solutions Publications.

Chase, C. C., Chin, D. B., Oppezzo, M. A., & Schwartz, D. L. (2009). Teachable agents and the protégé effect: Increasing the effort towards learning. *Journal of science education and technology*, *18*(4), 334-352.

Johnson, D. W. & Johnson, F. P. (2006). *Joining together. Group theory and group skills* (9th ed.). Boston: Allyn & Bacon.

Jolliffe, W., & Snaith, J. (2017). Developing cooperative learning in initial teacher education: indicators for implementation. *Journal of education for teaching*, *43*(3), 307-315.

King, A. (1997). Ask to think-tel why: A model of transactive peer tutoring for scaffolding higher level complex learning. *Educational Psychologist*, 32(4), 221-235.

Kobayashi, K. (2019). Learning by preparing-to-teach and teaching: A meta-analysis. *Japanese Psychological Research*, *61*(3), 192-203. Leung, K. C. (2015). Preliminary empirical model of crucial determinants of best practice for peer tutoring on academic achievement. *Journal of Educational Psychology*, *107*(2), 558–579.

Mitchell, S. N., Reilly, R. C., Bramwell, G., Slonosky, A., & Lilly, F. R. (2004). Friendship and choosing groupmates: Preferences for teacher-selected versus student selected groupings. Journal of Instructional Psychology, (31), 20-32.

Nickow, A. J., Oreopoulos, P., & Quan, V. (2020). The transformative potential of tutoring for PreK-12 learning outcomes: Lessons from randomized evaluations.

Pianta, R. C., Belsky, J., Houts, R. & Morrison, F. (2007). Opportunities to learn in America's elementary classrooms. *Science*, *315*, 1795–1796. Robinson, C. D., & Loeb, S. (2021). High-impact tutoring: State of the research and priorities for future learning.

Roscoe, R. D., & Chi, M. T. H. (2007). Understanding tutor learning: Knowledge-building and knowledge-telling in peer tutors' explanations and questions. *Review of Educational Research*, 77(4), 534–574.

Sherin, M., & van Es, E. (2005). Using video to support teachers' ability to notice classroom interactions. *Journal of technology and teacher education*, 13(3), 475-491.

Topping, K. J. (2005). Trends in peer learning. *Educational psychology*, *25*(6), 631-645.

Topping, K. J., Buchs, C., Duran, D., & Van Keer, H. (2017). *Effective peer learning: From principles to practical implementation*. Routledge.