Bridging AI and Mathematics Teacher Education: A Teacher Educator's Journey

Jonathan K. Foster (University at Albany)

My purpose with this article is to expand artificial intelligence (AI) literacy in the mathematics teacher educator community by reflecting on my journey working with a multidisciplinary team to develop AI tools for teachers and teacher educators. When I began collaborating with AI researchers and developers, I felt like I did not have much to contribute. However, I soon found that mathematics teacher educators' voices are critically needed to guide the development of AI for mathematics teacher education. By sharing my experience, I hope others will gain a greater appreciation of the potential of AI for mathematics teacher education and consider ways in which they might contribute their voice.

ChatGPT and other large language models (LLMs) have brought widespread attention to AI and its implications for education. Computer vision, like LLMs, is another area of AI application. Computer vision can broadly be defined as the extraction and interpretation of visual features from documents, images, or videos as input. Many modern automobiles have front-facing cameras with computer vision systems to assist drivers in detecting approaching vehicles or pedestrians. Other applications of computer vision have been taken up in various professions, such as medicine, to aid professionals in acting more efficiently or intelligently in the moment. For example, deep learning within computer vision systems has led to efficiencies in early detection of medical images (Saba et al., 2019). Given the proficiencies of these computer vision systems to assist professionals, my colleagues and I wondered how this application might extend into teacher education.

Emerging Video Technologies in Mathematics Teacher Noticing

Mathematics teacher education scholars have examined the use of videos for advancing teacher noticing, but few scholars have examined whether emerging technologies may support the development of teacher noticing (Santagata et al., 2021). These technologies have primarily included video annotation software or video animation software. AI, as an emerging technology, may facilitate (a) collecting data to support teacher noticing competencies and (b) documenting nuances in the development of teachers' abilities to notice within video-based programs. Furthermore, AI may expand the timeframe for teacher noticing, such as noticing trends in video segments across lessons. Next, I outline how the Artificial Intelligence for Advancing Instruction[1] (AIAI) team is taking up theoretical work from mathematics teacher noticing to design a teacher-facing analytics dashboard to support teacher noticing.

Artificial Intelligence for Advancing Instruction Dashboard

The AIAI team is developing deep neural networks for a computer vision application to classify instructional activities in videos of elementary mathematics and

[1] More information about the team and project can be found at https://aiaiproject.weebly.com.

English language arts (ELA) instruction (Foster et al., 2024). Furthermore, we are developing a teacher-facing analytic dashboard to share the outputs from the neural networks with teachers (Crimmins et al., 2023). We believe pairing video-based analytics with the video via a dashboard will support teachers' noticing and instructional improvement efforts and make the process of examining full-length lesson videos more efficient and engaging. We are gathering empirical evidence to recommend this new emerging technology as a complement to other video-based programs for supporting the development of teacher noticing.

The framework that guides our development of the teacher dashboard incorporates van Es et al.'s (2017) three recommendations for features that support teacher noticing. First, the dashboard will provide opportunities for teachers to *focus on student learning* when analyzing videos of their instruction with the aid of visual analytics. For instance, the dashboard will provide analytics about moments in the lesson when teachers take up and respond to students' ideas. Second, the dashboard will encourage teachers to *identify and describe teaching practices* as they are evident in their lessons. For example, the dashboard will indicate moments when teachers maintained, raised, or lowered the cognitive demand of a given task during a lesson and encouraged them to consider their teaching practices that maintained, raised, or lowered the cognitive demand. Third, the dashboard will promote *joint design, enactment, and shared noticing* as teachers will be able to share their lesson videos and interpretations of classroom interactions with peers or teacher educators. A group of teachers that co-designed a lesson, for instance, can share their lessons with each other, run various analytic comparisons, and discuss what they noticed from the comparative analytics and from watching the lessons. The next steps for our collective work include moving towards (1) understanding how the dashboard supports teachers and teacher educators in their work and (2) potential effects on their practice.

Why Mathematics Teacher Educators Are Needed

My work as a mathematics teacher educator on the AIAI team focused on developing a system for detecting instructional activities within classroom videos. These instructional activities were inspired by classroom observation protocols, specifically The Mathematics Scan (M-Scan; Berry et al., 2013) and the Protocol for Language Arts Teaching Observation (PLATO; Grossman et al., 2014). For example, one dimension of M-Scan is *students' use of mathematical tools*, which reflects opportunities for students to use tools to represent mathematical ideas during a lesson. These tools may include calculators, pattern blocks, fraction strips, counters, etc.

When joining the project, my responsibility was to instruct video annotators to reliably label moments in videos when these instructional activities occurred. As I examined video annotations, I noticed that several annotators conceived instructional tools in ways inconsistent with M-Scan. For instance, some annotators were labeling moments as using an instructional tool when students were holding clipboards. Although clipboards are a tool for organizing papers and support for writing, they are not (typical) mathematical tools as they do not represent or develop mathematical ideas. This important distinction is something that mathematics teacher educators would recognize but may have gone unnoticed by the machine learning specialists. Had these (mis)classifications been used for AI development, the results would not have been meaningful for mathematics education researchers, teacher educators, and teachers. In other words, it would have been nearly impossible to notice meaningful trends in the opportunities students were afforded or how students were developing their proficiency to strategically use appropriate tools. This experience is just one example in which mathematics teacher educators and practitioners are crucial to the design of AI-based applications.

Invitation to Mathematics Teacher Educators

My goal in working with the AIAI team is to develop AI-based applications that are useful for mathematics teachers and mathematics teacher educators. I admit the experience has stretched me professionally. There were times I felt I had little to contribute towards AI development. However, as I became more familiar with AI applications, I began to realize the potential for it to address some of the problems of practice mathematics teacher educators face. My perspective could guide the design of AI applications to address these problems of practice. I invite other mathematics teacher educators to consider contributing their perspectives to AI design and implementation in mathematics teacher education. A potential place to start is by joining the Google Group for Learning Engineering[2] to learn about opportunities to form potential partnerships with developers. Our collective voice needs to be heard to design meaningful and impactful AI systems.

References

Berry, R. Q., Rimm-Kaufman, S. E., Ottmar, E. M., Walkowiak, T. A., Merritt, E. G., & Pinter, H. H. (2013). *The Mathematics Scan (M-Scan): A measure of standards-based mathematics teaching practices*. University of Virginia.

Crimmins, S. B., Foster, J. K., & Youngs, P. (2023). *Automated neural network dashboards for teacher feedback*. Paper presented at the 2023 annual meeting of the American Education Research Association, Chicago, IL. https://doi.org/10.3102/2012634

Foster, J. K., Korban, M., Youngs, P., Watson, G. S., & Acton, S. T. (2024). Automatic classification of activities in classroom videos. *Computers and Education: Artificial Intelligence*, *6*, 100207. https://doi.org/10.1016/j.caeai.2024.100207

Grossman, P., Cohen, J., Ronfeldt, M., & Brown, L. (2014). The test matters: The relationship between classroom observation scores and teacher value added on multiple types of assessment. *Educational Researcher*, *43*(6), 293–303. https://doi.org/10.3102/0013189X14544542

Saba, L., Biswas, M., Kuppili, V., Cuadrado Godia, E., Suri, H. S., Edla, D. R., Omerzu, T., Laird, J. R., Khanna, N. N., Mavrogeni, S., Protogerou, A., Sfikakis, P. P., Viswanathan, V., Kitas, G. D., Nicolaides, A., Gupta, A., & Suri, J. S. (2019). The present and future of deep learning in radiology. *European Journal of Radiology*, *114*, 14–24. https://doi.org/10.1016/j.ejrad.2019.02.038

[2] https://groups.google.com/g/learning-engineering/about

Santagata, R., König, J., Scheiner, T., Nguyen, H., Adleff, A.-K., Yang, X., & Kaiser, G. (2021). Mathematics teacher learning to notice: A systematic review of studies of video-based programs. *ZDM – Mathematics Education*, *53*(1), 119–134. https://doi.org/10.1007/s11858-020-01216-z

van Es, E. A., Cashen, M., Barnhart, T., & Auger, A. (2017). Learning to notice mathematics instruction: Using video to develop preservice teachers' vision of ambitious pedagogy. *Cognition and Instruction*, *35*(3), 165–187. https://doi.org/10.1080/07370008.2017.1317125