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Board 425: Using Neural Networks to Provide Automated Feedback on Elementary Mathematics Instruction

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Using Neural Networks to Provide Automated Feedback on Elementary Mathematics Instruction[1]

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In recent years, several researchers have begun to use neural networks (i.e., a form of artificial intelligence) to provide automated classification of instructional activities in early childhood, elementary, and secondary classrooms (e.g., Author, 2022; Dale et al., 2022; Jacobs et al., 2022; Kelly et al., 2018; Ramakrishnan et al., 2019) in order to provide feedback to teachers on their instruction. For instance, neural networks can be trained to determine the percentage of time that teachers engage in whole group instruction, small group instruction, and individual seatwork during individual lessons in elementary classrooms (Author, 2022).

Another promising research development involves efforts to train neural networks to summatively evaluate different aspects of instruction in ways that are consistent with those of trained human raters. For example, Ramakrishnan et al. (2019) provide evidence regarding the promise of neural networks to engage in summative evaluation of videos of early childhood classrooms. But there has been little attention to applying neural networks to summative classroom observation measures aligned with elementary mathematics instruction. In addition, there has been little systematic research on how features of mathematics instruction may be associated with ratings of ambitious instruction by trained humans.

This study is designed to address these shortcomings in the research literature. We utilized 125 hours of videos of elementary mathematics lessons that had previously been rated by individuals trained in the use of the Mathematics-Scan (M-Scan) instrument (Berry et al., 2013). In particular, we examined correlations between the four M-Scan domains (i.e., mathematical tasks, discourse, representations, and coherence and (a) human annotations and (b) neural network classifications of individual features of instruction and combinations of aspects of instruction in the observed lessons.

In this paper, we report initial findings in three areas. First, we found that lessons with low amounts of transition time (i.e., non-instructional time) were more likely to be rated as coherent, with higher ratings for the structure of the lesson and mathematical accuracy. Second, lessons with high amounts of time allocated to small-group instruction were more likely to be rated highly in the task domain, with higher ratings for students' opportunities to engage in problem-solving, make connections, and engage in applications. Third, lessons with higher frequency of use of manipulatives and technology were more likely to be rated highly in the representations domain, with higher ratings for use of representations and use of mathematical tools. These results provide promising initial evidence that neural networks can be trained to accurately classify key elements of ambitious mathematics instruction.

In addition, we have developed a teacher dashboard for use in providing automated feedback to teachers on their mathematics instruction. In this paper, we report on qualitative data collected from six experienced elementary teachers on their perceptions of and experiences with teacher dashboard data (based on neural network analyses of videos of their own mathematics instruction). Our interactive, automated teacher dashboard is based on research on teacher noticing and video-based professional development (Desimone, 2008; van Es et al., 2014; 2017). Prior studies indicate that teachers are more likely to appropriate ambitious mathematics instructional practices when they have opportunities to engage in the following three video analysis practices. First, it is important for them to be able to examine features of instruction in videos such as the nature of teacher questioning, student discourse, student thinking, and feedback to students. Second, they are likely to benefit from elaborating on observations; this can include generating detailed descriptions of what happens in videos and/or making connections between aspects of ambitious mathematics instruction and what is observed. Third, it is important for them to make connections among observed practices in order to reason about mathematics instruction (van Es et al., 2017).

Our qualitative interview data from six teachers indicate that our dashboard promotes opportunities for them to use videos to engage in all three of these practices. First, the teachers were able to use the dashboard to investigate the nature and frequency of instructional activities such as teacher questioning, student discourse, and feedback to students based on neural network output; in particular, several of the teachers used this output to explore when these activities precede, co-occur, or follow other key aspects of instruction, Second, teachers reported using neural network output to consider connections between features of their practice and ratings of their enactment of ambitious mathematics instruction. As noted, each mathematics video had been rated with regard to several aspects of such instruction. Thus, teachers were able to assess how specific instructional activities related to such features of ambitious math instruction as cognitive demand, problem solving, and explanation and justification. Finally, they reported being able use neural network output to notice and respond to students effectively and reason about mathematics teaching and learning by making connections among different parts of their instruction.

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