

DESIGNING SIMULATIONS FOR ELICITING STUDENT THINKING: IS IT POSSIBLE TO DESIGN A COMPREHENSIVE STUDENT PROFILE?

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Prior work has shown that teaching simulations are valid and fair ways to assess novices' skills with eliciting student thinking. In this study, we sought to explore a fundamental question about the use of live, interactive simulations, that is, whether it is possible to design a student profile that sufficiently covers the breadth of questions that preservice teachers might ask during an interaction. Our results reveal that it is possible. Implications are discussed.

Keywords: Assessment and Evaluation; Instructional activities and practices

Successful teacher preparation requires innovations in assessment that can inform preservice teachers (PSTs) and those who prepare them. Of particular importance are assessments that provide information about PSTs' abilities to actually do the core tasks of teaching. This requires combining instructional techniques together with specialized knowledge of the content and insights into students' thinking and development. Although many current assessments of teaching, including observation tools (e.g., Danielson, 2013) and portfolios (e.g., Teacher Performance Assessment developed by Darling-Hammond and Pecheone, 2010), do offer useful information, additional tools are needed to supplement what can be learned through these types of assessments. Further, we must move beyond traditional forms of assessment to create sustainable and fair ways to assess such capability throughout initial teacher preparation.

In recent years, the use of simulations in teacher education has expanded and there is growing interest in the use of simulations for learning and assessment. By *simulation*, we mean a live instance in which a preservice teacher (PST) interacts with an adult whose actions are guided by a profile of a K-12 student's reasoning about content and responding to questions. In such a simulation, PSTs are engaged in the interactive work of teaching and there are opportunities for teacher educators to see and appraise PSTs' developing capabilities and skills (Shaughnessy & Boerst, 2018). This work builds on the use of live, interactive simulations in medicine, dentistry and other professional fields. Doctors and dentists in training engage in simulations of physical examinations, patient counseling, and medical/dental history taking by interacting with "standardized patients." Evaluation of medical students' interactions with standardized patients makes possible common and sustainable appraisal of candidates' knowledge and skills (Boulet, Smee, Dillon, & Gimpel, 2009).

The use of simulations in teacher education has been growing (e.g., Dieker et al., 2014, Dotger, 2015; Dotger & Sapon-Shevin 2009; Mikeska & Howell, 2018; Self, 2018), but there has been limited research on the design of simulations that would be needed for wider-scale use. In this paper, we build on our past efforts to design and study the use of simulations to assess PSTs' skill with eliciting and interpreting student thinking. Specifically, we investigate the robustness

of the design of the simulation. In the particular version of simulations that we develop, we design a “student role protocol” which captures the student’s process and understanding and the ways in which they respond to questions about their mathematical work. The “student” uses information from the protocol to guide the ways in which they respond to questions posed by the PSTs. In this study, we examined a student role protocol that we developed for one such simulation and video records of PSTs’ performances. We investigated how and to what extent the student role protocol provided guidance in responding to questions posed by PSTs.

Design Considerations for Simulation Assessments

Since 2011, we have been developing and studying simulations as a means to assess PSTs’ capabilities with eliciting and interpreting student thinking. We have used simulations to learn about the eliciting and interpreting skills that novices bring to teacher education as well as to assess their progress as they move through their professional training. In our simulations, PSTs engage in three stages of work. First, they are provided with student work on a mathematics problem and given 10 minutes to prepare for an interaction. The task for the PST during the interaction is to determine the process the student is using to solve the problem and the student’s understanding of the core mathematical ideas involved in the process. Second, PSTs interact with a “student.” The role of the “student” is carried out by a teacher educator whose words and actions are guided by a student role protocol. As described above, the protocol is a detailed profile of a particular student’s thinking and rules that govern this student’s interactional norms. PSTs have five minutes to interact with the “student,” eliciting and probing the “student’s” thinking to understand the steps she took, why she performed particular steps, and her understanding of the key mathematical ideas involved. In the third stage, PSTs respond verbally to a set of questions that are designed to probe their interpretations of the “student’s” process and understanding and their prediction about the “student’s” performance on a similar problem.

Our assessment development process considers teaching practice itself and how it can be decomposed for the purposes of assessment. We also consider the assessment situation and the opportunities it creates for PSTs to demonstrate their skills in light of a practice-focused developmental frame (see Shaughnessy & Boerst, 2018 for more details). In our simulation assessments, the student role protocol (see Figure 1 for an excerpt) is crucial both for enacting the assessment and for providing consistent opportunities for PSTs to demonstrate their capabilities with eliciting student thinking. We have three main design considerations (Shaughnessy & Boerst, 2018). The first is the *mathematics content* itself that is embedded in the student work sample. The second is the *characterization of the student’s process and understanding*, including the student’s process for solving the problem, the student’s understanding of the process and related mathematical ideas, and the accuracy of the student’s answer. The third is the *student’s way of being*, which refers to the student’s dispositions, interactional style, and use of mathematical language. A student role protocol articulates each of these considerations and this constitutes general guidance for responding to PSTs’ questions. We also script responses to likely questions that are aligned with the three design considerations.

Methods

Thirty-six PSTs enrolled in an undergraduate university-based elementary teacher education program in the United States participated. The assessment was administered at the mid-point of the teacher education program as a regular part of the program. The performances on assessments were video recorded and written artifacts were collected. We used the software

package Studiocode© to code the assessment video. We began by parsing the video into talk turns. Then we identified what we refer to as “cases” which contain a question posed by a PST. For each case, we characterized the question posed by the PST using one of three codes:

- *Scripted response available:* A scripted response exists in the student role protocol that could be used to respond to the question posed by the PST
- *No scripted response, but there is general guidance:* No scripted response exists in the student role protocol that could be directly used to respond to the question posed by the PST; however, the general guidance provides information that might be used in response
- *Guidance not available:* There is no scripted response in the student profile that can be used to respond to the PST’s question and no guidance for responding to the student is available in the general guidance section

Two coders independently coded each video. Discrepancies in scoring were examined by the full team, referencing the codebook as needed to reach consensus.

<p>Mathematics topic: Comparison of fractions</p> <p>Characterization of the student’s process and understanding:</p> <p>The student’s process: The student is using the common numerator method to compare fractions. To determine which numerator to use, the student finds the least common multiple of the numerators of the original fractions. The student generates equivalent fractions by multiplying the numerator and denominator of each fraction by the same number. Then the student compares the denominators to determine which fraction is larger.</p> <p>The student’s understanding of the ideas involved in the problem/process: The student knows you have to multiply (or divide) the numerator and denominator by the same number to generate an equivalent fraction but does not understand why that process works. Once the student has common numerators, the student understands that when you have the same number of pieces, you can use the denominator to determine which fraction has larger pieces and therefore which fraction is larger.</p> <p>Other information about the student’s thinking, language, and orientation in this scenario: The student knows of other strategies for comparing fractions, but the student thinks that the common numerator methods works best with the given example.</p> <p>The student’s way of being: The standardized student gives the least amount of information that is still responsive to the PST’s question.</p> <p>Specific responses based on the identified mathematics topic, characterization of the student’s process and understanding, and the student’s way of being (a subset of them):</p>	$\frac{3}{7} = \frac{6}{14} \quad \frac{2}{5} = \frac{6}{15}$ $\frac{6}{14} > \frac{6}{15}$ <p>So: $\frac{3}{7} > \frac{2}{5}$</p>								
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr style="background-color: #cccccc;"> <th style="width: 50%;">PST prompt</th> <th style="width: 50%;">Response</th> </tr> </thead> <tbody> <tr> <td>What did you do first?”</td> <td>“I wanted to change the fractions so that there would be something in common.”</td> </tr> <tr> <td>Asks about how 6 was identified as the common numerator</td> <td>“I wanted the numerator to be 6 because it was the least common multiple.”</td> </tr> <tr> <td>“Why can you compare fractions by comparing the denominators when the numerators are the same?”</td> <td>“When you make the numerators the same it means you have the same number of</td> </tr> </tbody> </table>		PST prompt	Response	What did you do first?”	“I wanted to change the fractions so that there would be something in common.”	Asks about how 6 was identified as the common numerator	“I wanted the numerator to be 6 because it was the least common multiple.”	“Why can you compare fractions by comparing the denominators when the numerators are the same?”	“When you make the numerators the same it means you have the same number of
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	parts so all you need to think about is how big the parts are.”
“Why is $6/14$ greater than $6/15$?”	“Fourteenths are larger than fifteenths.”

Figure 1: An Excerpt from the Student Role Protocol

Results

Our analysis focused on the extent to which the student role protocol provided guidance in responding to questions posed by PSTs. Across the 36 performances, there were 457 cases in which PSTs posed a question to the “student.” In 70% of the cases (319 of the 457), a scripted response was available in the student role protocol. For example, one PST asked, “how did you pick 6 as the common numerator?” There is a scripted response for “asks about how 6 was identified as the common numerator.” In another 25% of the cases (112 of the 457), there was no scripted response available, but the “student” could respond by drawing on other guidance provided in the student role protocol, such as information provided about the student’s understanding of relevant mathematical concepts and general demeanor. For example, one PST posed an additional problem for the student to solve in which the student generated equivalent fractions which had a common numerator of 12. The PST then asked the student, “How did you use 12 as the numerator?” The response for this exact question was not scripted but the PST could reasonably use the general information available in the profile and the scripted response for a common numerator of 6 to generate a response to the question. Another way of interpreting these findings is that for 95% of the questions posed, there was some guidance available in the student profile for responding. These results suggest that the student profile is sufficient for providing guidance to the “student” for responding in standardized ways.

In the remaining 5% of the cases (26 of the 457), there was no guidance available in the profile for responding to the question. This means that in these cases, the “student” had to improvise to construct a response to the question. We examined how these 26 cases of “no guidance in the profile” were distributed across PSTs. Because the PSTs asked varying numbers of questions, we calculated the percentage of “no guidance” cases for each PST. We found the percentage of instances in which no guidance was available ranged from 0% to 29% with mean of 5% and a standard deviation of 10%. There were 5 PSTs for whom the percentage of cases with no guidance available was higher than 15%. This suggests that cases of “no guidance” were somewhat idiosyncratic and clustered around a small subset of PSTs .

Discussion

Our study establishes that it is possible to design a “student role protocol” with scripted responses that address the vast majority of questions posed by PSTs in a simulation. Further, in the case of this simulation, it was crucial to provide a general frame for how the student was thinking in addition to scripting responses to specific questions. The general guidance was needed to respond to 25% of the questions posed in the study. Further, because interpreting an unscripted question and determining an appropriate response based on guidelines are complex activities, these findings suggest that it is necessary to have a live “student” ready to take up unique lines of questioning. As part of a broader study, we are investigating the fidelity of the implementation (i.e., the degree to which “students” responses adhere to the profile). Results from our analyses are promising. Individually any of these questions is important, but as a set they constitute what Cohen and Ball (2007) characterize as “scaling in” to establish internal components of the initial intervention that is a crucial precursor to scaling up.

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