EasyChair Preprint

№ 10153

Exploring Data Visualization in Mixed Reality Simulations to Measure Teacher Responsiveness

Rhonda Bondie, Zid Macenido, Happi Adams and Chris Dede

May 13, 2023

Exploring Data Visualization in Mixed Reality Simulations to Measure Teacher Responsiveness

Rhonda Bondie [1][0000-0002-4062-3726] Zid Macenido[2] Happi Adams[2] and Chris Dede[2]

[1] Hunter College, New York, USA
[2] *Harvard University,* Cambridge, USA
lncs@springer.com

Abstract. A growing body of research begins to illustrate how mixed reality simulation (MRS) based on digital puppeteering (e.g., Mursion) may be used to provide practice-based opportunities in teacher education. Ironically, current research of this new technology often uses historic measures and conventional data analytics to measure teacher learning, such as holistic rubrics of qualities that describe an average or overall teacher performance or frequency counts of teaching behaviors. What is missing from the literature are novel approaches to measures, data collection and analyses that leverage the digital data available through MRS to explore new dynamic and responsive measures of teaching. For example, measurement of teacher growth could shift from focusing on teacher performance and behaviors to measuring teacher responsiveness to student variances. Rather than just measuring the extent to which a teacher can implement a specific teaching practice, researchers could examine the extent that the teacher adapted the teaching practice or selected appropriate teaching strategies based on qualities perceived in student responses. Now more than ever, we need innovation in teaching, especially developing teacher capacity to perceive and respond to student diversity in real time as learning unfolds. This study explored possible MRS measures and data analytics that examine teaching as a dynamic process responsive to student diversity. We found that specific elements of simulation design and implementation can generate data that measures indicators of teacher responsiveness to student variance.

Keywords: Immersive Learning, Teacher Education, Mixed Reality Simulation, Data Analysis, Virtual Performance Simulations.

1 Introduction

Increasingly, teacher education programs have explored mixed-reality simulations (MRS) as a means for teaching practice [1]. Figure 1 illustrates a MRS, using Mursion software, where a trained actor-coach digitally puppets student avatars in a 3D virtual classroom accessed by teachers through Zoom. This software is referred to as mixed reality because there is an unseen human being controlling the avatars in the virtual world. The realistic practice environment may create a strong sense of presence and focus, and potentially increase near transfer [6]. Teacher education research has demonstrated that rehearsals, such as MRS, can develop teachers' ambitious instructional practices [11], [9]. However, Philip, et al. (2019) criticized teaching rehearsals arguing

that “decontextualized moves” and technical efficiency are gained at the expense of responsiveness to student needs as learning unfolds (see also [15]). Teaching rehearsals may not provide “the stable groundwork within which rich responses to student performances can be improvised” [11, p. 498]. Rather, these “rigid conceptualizations of practice and prescriptiveness [separate] the teachers’ social and cultural identities from what they are able to actually do in a classroom: how they can respond, what they can convey, and to whom” [12, p. 257]. Given this debate, more empirical research is necessary that explores the extent that teaching rehearsals can promote teachers’ responsiveness to their students’ diverse and spontaneous needs.

Educators find that adjusting teaching in response to the wide range of student reading strengths is challenging [4]. Rigorous academic discussions in early elementary grades support literacy growth through vocabulary development, comprehension, and engagement in academic tasks. Therefore, our MRS aimed at improving teacher ability to adjust peer discussion directions to increase the quality of student responses and equity in participation when avatar students were given a task of discussing a comparison of two photographs.

Previous MRS studies have described learning growth through frequencies of desired teacher actions [7], [5]-[8]. However, MRS studies have not measured the extent that teachers adjust their practice in response to diverse learner needs. Addressing this void, this exploratory study examined how teaching was adjusted in response to digital puppeteering of avatar students during multiple MRS trials. Two research questions guided our exploration:

1. How do teachers’ adjustments to peer discussion directions align with avatar student demonstrated learning needs regarding response quality and equity in participation?
2. How do simulation design features of a) coaching versus self-reflection time and b) multiple trials impact teaching adjustments?

2 Methods

2.1 Participants

The study recruited seven teachers engaged in an alternative secondary certification graduate teacher education program in the Northeast United States. All participants were undertaking their first practicum in the same summer high school. Participants were recruited in person by one of the authors during a compulsory teaching methods course; there were no benefits or requirements in engaging in the study. The treatment group consisted of four teachers, two identified as male teaching math and two as female teaching science and social studies. The control group had three participants, two identified as female teaching social studies and science, and one as male teaching social studies. Participants were not explicitly told that they were in a particular treatment group.

2.2 Procedure

Teachers were provided with preparation materials for the peer-to-peer discussion task used during the simulation and specific strategies to adjust directions in response to student learning needs (see https://wke.lt/w/s/OSIEuF). Each teacher completed the MRS individually via Zoom. (see, Figure 1). The treatment group received coaching from an avatar coach that was controlled by the simulation specialist. The control group received individual planning time in an empty virtual classroom with no coaching from the simulation specialist during the simulation. The white female simulation specialist was highly skilled with MRS and had P-12 teaching experience. The simulation specialist completed the script development, rehearsal, and seven simulations in 12 hours. The researchers developed the script collaboratively with the simulation specialist to rehearse if-then responses to possible direction elements for the avatar student pair discussions. The avatars were both controlled by the software and the simulation specialist used voice morphing software and equipment to capture the simulation specialists movement. Because one simulation specialist controlled the class of students, only one student could speak at one time.

Fig 1. Mursion Virtual Classroom

2.3 Data Sources and Analysis

Automated transcripts generated from Zoom were cleaned, then analyzed using constant comparison analysis and in vivo using a line by line approach to examine each utterance during the simulation [14]. Three coders independently coded all transcripts, then the research team discussed the codes and reduced them into specific elements for adjusting directions [13]. The researchers were two US white women; one, a faculty member with more than twenty years of teaching experience and the other, a graduate student who currently teaches high school English, and an Australian male who was also an experienced teacher. Throughout the process, the team evaluated personal assumptions and biases that influenced perceptions of the data collected and analysis. Member checks were completed with four participants to ensure coding accuracy.

3 Results

The first research question explored how teachers' directions aligned with the avatar students discussions. In Figure 2, the shade of each box illustrates the presence of specific qualities in teacher directions across three trials. Starting from the center moving left across Figure 2, shaded cells represent each trial and indicate teachers' explicit attention to specific elements of high quality student responses (i.e., evidence, academic language, and compare and contrast thinking) and, toward the right, we see equity in

discussion participation (i.e., tools for supporting student social regulation including teacher articulation of student discussion roles, rules, turn taking, and time). For example, teachers could use the equity elements in their directions to address challenges such as one student dominating the conversation.

Each row in the figure represents a different teacher; the treatment coaching group are above the center row of compare and contrast thinking) and, toward the right, we see equity in discussion participation (i.e., tools for supporting student social regulation including teacher articulation of student discussion roles, rules, turn taking, and time). For example, teachers could use the equity elements in their directions to address challenges such as one student dominating the conversation. A plus (+) sign means the element was added from the previous trial and a negative (-) symbol means the teacher direction element had been present in the previous trial, but was not present in the next trial.

The red circle indicates that at least one avatar student responded to the teacher directions by including that element in their response (e.g., the teacher gives examples of academic vocabulary that can be used and then the avatar students used those words in their peer discussion). When a box is white, not shaded, but has a circle, it means that the avatar students had the element in their discussions; however, the teacher did not specifically ask for the element in the teacher directions. An X in a box identifies an element that was present in student responses; however, the students were incorrect (e.g. students using vocabulary incorrectly or used background knowledge instead of evidence from the photographs to support an inference). The frequency of each element by individual participant is shown in the numbers along the end vertical columns. For example, Teacher 1 included 4 high quality elements in their directions and 8 equitable student participation elements. The total number of elements for each treatment group is shown in the corner and by each trial along the top for the coaching-treatment group and along the bottom for the control – self-reflection group. The key at the bottom of the figure identifies each symbol.

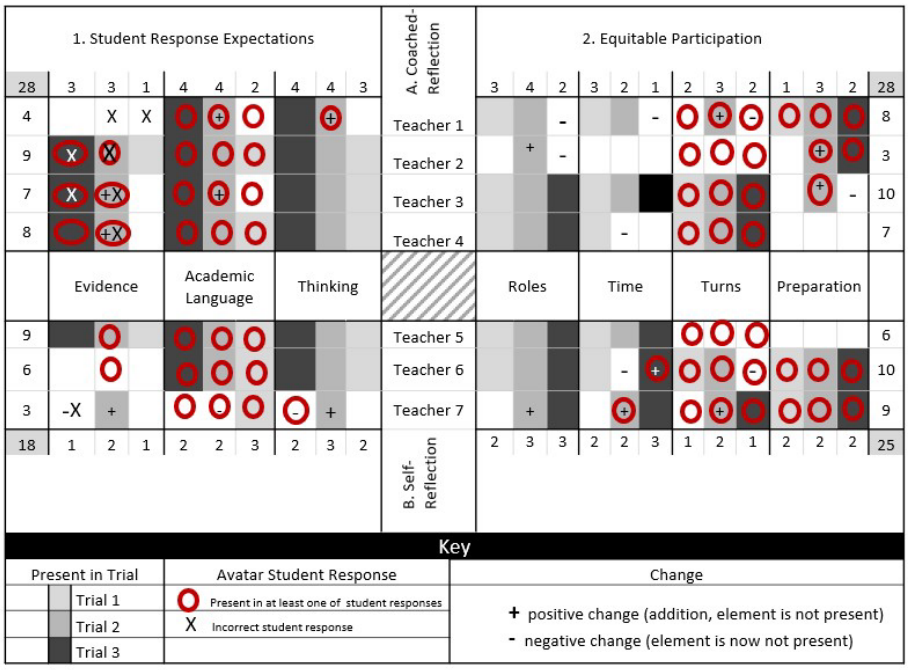

Fig. 2 Teacher direction elements and avatar responses match by teacher and trial

The second research question explored how the MRS design features of coaching versus self-reflection time and multiple trials shaped teaching adjustments. Frequency counts along the outside of Figure 2 reveal that the coaching group implemented 28 out of 36 or 75% of the possible teacher direction elements aimed at increasing the quality of student responses. The control group implemented 18 out of 27 possible elements across three trials or 67%. There were four equity elements for each of three trials for each teacher in the treatment (48 total elements) and control (36 total elements). The treatment group used 28 elements or 56% and the self-reflection group used 25 elements or 69%. Teachers in the treatment group seemed to focus more on high quality responses than equitable participation in their discussion directions. The teachers assigned to self-reflection included about equally elements focused on academic quality and equitable participation. Figure 3 displays the total number of elements used in teacher directions by trial and coaching versus the self-reflection group. Surprisingly, teacher use of the direction elements did not increase in a linear manner over the three trials. Instead most teachers increased the number of elements in their directions from trial 1 to trial 2, but decreased their use of direction elements in trial 3. No teacher included all 7 direction elements.

Taken together, Figures 2 and 3 demonstrate how the elements in teacher directions may vary. For example, Figure 3 shows that Teacher 1 and Teacher 2 both had 3 elements in their trial 1 directions. However, when investigating the three elements using Figure 2, we see that Teacher 1 focused on equitable participation elements while Teacher 2 focused on the high quality responses without attention to equity in

participation. Another example, when looking at Teacher 7 in Figure 3, we see the fewest elements in trial 1 directions and the greatest growth in trial 2 by adding four elements. However, when investigating specific changes we see that the teacher focused almost exclusively on student participation with little attention to the quality of what students were saying in their discussion. Visualizing the elements of the complex teaching practice of giving directions with the impact of those directions on student responses illuminates the diversity in teacher learning and how growth in one aspect of the practice (e.g. equitable participation) does not necessarily lead to higher quality in student responses.

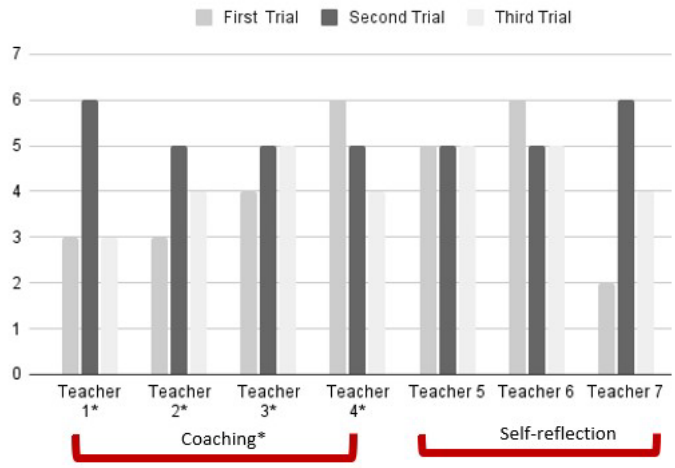

Fig. 3 Total Direction Elements Across Three Trials

4 Discussion

This exploratory study investigated the extent that three trials led to teacher adjustments of peer discussion directions in response to perceived student learning needs. The central contribution of this small study is the exploration of visualizing teacher learning in MRS as dynamic and related to student learning needs versus a decontextualized count of teaching behaviors. This study employed qualitative line by line coding of teacher and avatar student utterances. The analysis approach used in this exploratory study of qualitatively coding language at the utterance level and then visualizing responsiveness to student demonstrated needs holds the potential for examining teaching as interaction versus a static implementation process. Further, this study demonstrates that professional learning within MRS moves forward and backward as well as remaining constant. Most importantly, visualizing both the teacher and the avatar student responses together, we can see how the simulation specialist may influence teacher experiences and learning within MRS. When examining each row in Figure 2 representing a teacher direction element across three trials separated by elements promoting high quality

student responses and equitable student participation, teaching appears more like a dance than an assembly line.

In summary, our results illustrated changes in teaching practices across a repeated practice model. We observed that repeated practice did not lead to continuous growth in teacher direction elements. In fact, teacher use of the discussion direction elements generally rose and then fell, with fewer elements used in the final trial. This may have been a result of the simulation specialist needing more challenges in the script for avatar discussions, teachers may have become tired, or the repeated practice of the same task may have lost cognitive interest for teachers. This exploratory study illuminates questions regarding the number of trials needed for mastery of teaching practices and the concern about repeated practice when an appropriate challenge isn't present in student response or when teachers are tired from the effort required to sustain focus in the MRS may lead to the rehearsal of less effective teaching practices. Our analyses suggest that both planned and improvised avatar responses and interactions may influence the growth of teaching practices.

5 Implications

5.1 MRS Designers

The contributions of this short paper are the innovative use of avatar puppeteering for the orchestration of realistic teacher training simulations and the proposed visual data coding method. More specifically, our exploration surfaces four important factors that impact MRS design. First, to promote teacher responsiveness, the simulation should begin with the teacher listening to students and then adjusting teaching in response. This centers responding to student variation in learning as the goal of teaching. Second, MRS practice should be personalized. For example, during the third trial teachers could have been given a choice to restart the MRS from the beginning, continue where they had left off in trial 2, or move on to a transfer task of giving directions for a new pair discussion. Offering personalized practice leverages the affordances of MRS versus real-life rehearsals in schools and provides optimal challenge so that teachers benefit from each MRS trial. Third, the number of trials and length of MRSs needs further exploration about what is effective. Fourth, research is needed on how MRS learning can be tailored to teacher needs and the MRS conditions that promote effective coaching.

5.2 Simulation Specialists

By analyzing avatar responses, this study lifts up the importance of a simulation specialist fully understanding the task and specific vocabulary that students might use in their responses based on age level and experiences. Simulation specialists must understand the ways that student thinking and responding might vary. MRS designers and simulation specialists should try the MRS tasks with real students in schools to gain insight into possible student responses. It is important to plan not only standard challenges in the script, but the extent to which avatar students will persist with incorrect

ideas or offer mistakes to increase the complexity of the teacher's task. Simulation specialists need to be well versed in the elements of complex teaching practices. For example, coaching in this study did not lead to teachers increasing teaching elements focused on equitable participation, however, teachers given self-reflection increased equity elements. This could be that the simulation specialist was not familiar with the teaching elements and did not recognize when the teacher used the elements in their discussion directions. Being able to not only puppet the students, but recognize the presence and absence of discussion direction elements was essential for both coaching and avatar responses to teacher directions.

5.3 Teachers, Teacher Educators, and Researchers

The Xs in Figure 2 illustrate opportunities for teachers to correct a student mistake. We observed no teachers correcting mistakes. Even in the virtual classroom, teachers did not draw student attention to errors. Future studies should explore why teachers correct students or ignore student errors. Further, research might investigate how teachers adjust when the avatar student does not follow their directions. For example, does the teacher repeat the directions, ask for questions, or embellish the directions with more information?

5.4 Limitations

The small sample size limits any generalizations beyond the current study. A larger sample in a replication study would increase the number of utterances examined and may reveal additional codes. There was no pre-post measurement limiting information on pre-simulation participant equivalence. Within these limits, this exploratory study illuminated specific simulation design elements and provided evidence of the potential insights gained from analyzing simulation interactions that can inform future simulation design and research.

6 Conclusion

Now more than ever, we need innovation in teaching, especially developing teacher capacity to perceive and respond to student diversity in real time as learning unfolds [3]. This study explored possible ways to visualize teacher learning in MRS as interactions with students. This approach supports the future work of technologists, teacher educators, and educational researchers in transforming teacher professional learning from an industrialized machine-like approach to teaching to instead a dynamic process responsive to student diversity. Specifically, this study illuminates MRS design choices, such as the importance of personalized practice and use of coaching and self-reflection that leverage the MRS technology affordances. This exploratory study sets the stage for further research aimed at transforming standard teacher professional development (PD) to experiences that nurture responsive and improvisational aspects of teaching necessary to meet the diverse learning needs of students by providing PD that also responds to the individual learning needs of teachers [2].

7 Acknowledgement

This research was part of the Reach Every Reader initiative supported by the Chan Zuckerberg Foundation.

References

1. American Association of Colleges of Education (AACTE, Producer). (2020). Let's test drive classroom simulation.[Webinar Series]
2. Bondie, & Dede, C. (2021). Redefining and transforming field experiences in teacher preparation through personalized mixed reality simulations. In R. E. Ferdig & K. E. Pytash (Eds.), What teacher educators should have learned from 2020. Association for the Advancement of Computing in Education (AACE).
3. Bondie, Mancenido, & Dede, C. (2021). Principles for designing virtual humans to develop teachers' responsiveness towards diverse learners. Journal of Research on Technology in Education, 53(1).
4. Bondie, R. & Zusho, A. (2018). Differentiating Instruction Made Practical: Engaging the Extremes Through Classroom Routines. New York: Routledge.
5. Dawson, M. R., & Lignugaris/Kraft, B. (2017). Meaningful Practice: Generalizing Foundation Teaching Skills From TLE TeachLivETM to the Classroom. Teacher Education and Special Education, 40(1), 26–50.
6. Dede, C. J., Jacobson, J., & Richards, J. (2017). Introduction: Virtual, augmented, and mixed realities in education. In Virtual, augmented, and mixed realities in education (pp. 1-16). Springer, Singapore.
7. Dieker, L. A., Rodriguez, J. A., Lignugaris/Kraft, B., Hynes, M. C., & Hughes, C. E. (2014). The potential of simulated environments in teacher education: Current and future possibilities. Teacher Education and Special Education, 37(1), 21-33.
8. Kannan, P., Zapata-Rivera, D., Mikeska, J., Bryant, A., Long, R. & Howell, H. (2018). Providing Formative Feedback to Pre-service Teachers as they Practice Facilitation of High-Quality Discussions in Simulated Mathematics and Science Methods Classrooms. In E. Langran & J. Borup (Eds.), Proceedings of Society for Information Technology & Teacher Education International Conference (pp. 1570-1575). Chesapeake, VA: Association for the Advancement of Computing in Education (AACE).
9. Kavanagh, S. S., & Rainey, E. C. (2017). Learning to Support Adolescent Literacy: Teacher Educator Pedagogy and Novice Teacher Take Up in Secondary English Language Arts Teacher Preparation. American Educational Research Journal, 54(5), 904–937.
10. Lampert, M., & Graziani, F. (2009). Instructional activities as a tool for teachers' and teacher educators' learning. The Elementary School Journal, 109(5), 491-509.
11. Loewenberg Ball, D., & Forzani, F. M. (2009). The Work of Teaching and the Challenge for Teacher Education. Journal of Teacher Education, 60(5), 497–511.

12. Philip, T. M., Souto-Manning, M., Anderson, L., Horn, I., J. Carter Andrews, D., Stillman, J., & Varghese, M. (2019). Making Justice Peripheral by Constructing Practice as “Core”: How the Increasing Prominence of Core Practices Challenges Teacher Education. Journal of Teacher Education, 70(3), 251–264.
13. Saldaña, J. (2009). The qualitative coding manual.
14. Strauss, A., & Corbin, J. M. (1997). Grounded theory in practice. Sage.
15. Zeichner, K. (2012). The Turn Once Again Toward Practice-Based Teacher Education. Journal of Teacher Education, 63(5), 376–382.