2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #51260

Methods to Develop Digital Discussion-Based Simulation Scenarios for Engineering Education Research: A Framework and Example

Dr. Pamela S. Lottero-Perdue, Towson University

Pamela S. Lottero-Perdue, Ph.D., is Professor of Science and Engineering Education in the Department of Physics, Astronomy & Geosciences at Towson University. She has integrated engineering into courses for PreK-8 teacher candidates, developed and directed a graduate STEM program for PreK-6 teachers, and partnered with teachers to implement PreK-8 science-integrated engineering learning experiences. She has authored numerous engineering-focused teacher practitioner articles, chapters, and research articles, and presents her research regularly through the ASEE Pre-College Engineering Education Division, a division she has chaired. Her current research includes investigating how K-20 students plan, fail, and productively persist, and how simulated classroom environments can be used to help educators practice facilitating discussions in science and engineering.

Dr. Haritha Malladi, University of Delaware

Haritha Malladi is an Assistant Professor of Civil and Environmental Engineering and the Director of First-Year Engineering at the University of Delaware. She received her Bachelor of Technology degree in Civil Engineering from National Institute of Technology, Warangal, India, and her MS and PhD in Civil Engineering from North Carolina State University. She is a teacher-scholar working in the intersection of undergraduate engineering education, sustainable infrastructure, and community engagement. She teaches the introductory engineering course for all first-year undergraduate students in the College of Engineering at UD. Her undergraduate teaching experience includes foundational engineering mechanics courses like statics and strength of materials as well as courses related to sustainability and infrastructure. Her research interests are in foundational engineering education, sustainability in engineering curriculum, and green technologies in infrastructure.

Dr. Marcia Gail Headley, University of Delaware

Dr. Headley conducts educational research at the Center for Research in Education and Social Policy (CRESP) at the University of Delaware. In her role as a Data Scientist, she uses both qualitative and quantitative data sources and analytical strategies. She specializes in the development of mixed methods research designs that incorporate qualitative strands of inquiry, quantitative data strands of inquiry, and mixed methods integrative analysis across the strands of inquiry.

Methods to Develop Digital Discussion-Based Simulation Scenarios for Engineering Education Research: A Framework and Example

Introduction

In this full-length methods paper, we offer a methods framework for developing digital discussion-based simulation scenarios to support engineering education research. We built this framework from the simulation literature in teacher education and medical education, and have implemented it in our research [1, 2]. Discussion-based simulations are those that enable participants to facilitate simulated discussions. Digital versions involve participants interacting with a software platform and using information contained in a scenario to inform their interactions.

In the remainder of this introduction, we ground readers in basic ideas about simulations, simulation platforms, and simulation scenarios; address the difference between technical and discussion-based simulations; and summarize the scant current research on discussion-based simulations in engineering education. The background section that follows provides insights from teacher education and medicine, each having more extensive histories of using digital discussion-based simulations for research purposes. Then, we present our main methodological contributions, i.e., a framework of principles for designing digital discussion-based scenarios for use in research. We also share a synopsis of our use of this framework to develop and implement discussion-based scenarios for research within the Discussing Team Conflict Project, which investigates how undergraduate teaching assistants, who serve as near-peer mentors, facilitate simulated discussions with a first-year engineering team in conflict.

Broadly, simulations engage participants in some aspects of a real task while intentionally omitting others. Before we address discussion-based simulations, it may be useful for readers to consider technical simulations, which are more common in engineering education [3]. Technical simulations include the use of computational fluid dynamics software to model fluid flow [4] and simulated laboratory experiences to support engineering learning [5]. Another example is a flight simulator for pilots in training or flight systems engineers. These typically have a physical or virtual-reality cockpit that to the participant, looks, feels, and acts like the cockpit of a real plane [6, 7]. We would refer to this system as the simulation platform. The situations that participants consider for use within the platform are the scenarios, such as tricky takeoffs or emergency situations (e.g., bird strikes). Omitted from a flight simulator would be flying a real plane with real passengers. In this way, the flight simulator approximates the use of the actual machine without putting humans, including the pilots or passengers, or an expensive aircraft at risk. Flight and other technical simulators are not only used for learning and training but also for research, e.g., to study pilot behavior as they interact in a simulated cockpit [8].

Discussion-based simulations focus on participants' communication with people. To date, the use of discussion-based simulations for learning or research has been reported rarely in the engineering education literature. Examples include investigations of how pre-service and in-service elementary and middle-school teachers facilitate challenging discussions during engineering design [9-11]; a study of how non-interactive simulated audience members can be used to help engineering undergraduates prepare for their capstone presentations [12]; and our work from the Discussing Team Conflict Project [13-15].

Despite this low frequency of reported use in engineering education, discussion-based simulations have the potential to support both professional learning and research related to communication in engineering education. Communication is an essential skill for engineers. For example, page six of the ABET criteria for accrediting engineering programs states that undergraduate engineering students need to develop the ability to "communicate effectively with a wide range of audiences" and "function effectively on a team," which includes communication skills [16]. Our focus in this paper is on how discussion-based simulations can be used to support *research* on communication within undergraduate engineering education.

Background

Here, we draw from the literature on discussion-based simulations in teacher and medical education where they have been used widely [17]. For each of these fields, we present a non-digital example before sharing examples that incorporate digital technology. We differentiate each example's simulation *platform* (e.g., a simulated plane cockpit) and *scenarios* that can be used within the platform (e.g., experiencing a bird strike). We conclude by summarizing how digital discussion-based simulations have been used for research purposes in these fields.

Teacher Education

In teacher education, discussion-based simulations have been used for well over a century to support teacher professional learning—with the first reference to simulated practice made in 1865 [18]. A common form of simulation is in-person role-play—also called microteaching, peer teaching, or rehearsal—within teaching methods courses [19-22]. These simulations entail having (a) one or more pre-service teachers play the role of the teacher and (b) others play the role of their students. Instructors prepare different sets of materials, including information and instructions, for these two roles. Student role-players use their materials to inform how they simulate students. Teacher role players use their materials to understand discussion goals and context. In this simulation, the platform is the teacher education course with expectations and norms for role play. The scenario, described in the materials, represents what the discussion is about (e.g., a discussion to help students make sense of a collision investigation [23]).

A simple digital version of this teacher-student role play is the Eliciting Learner Knowledge simulation from MIT Teaching Systems Lab [24, 25]. In this simulation, pre-service teachers work in pairs with one acting as the teacher and the other acting as a student; the goal of the pre-service teacher in the teacher role is to elicit what the pre-service teacher in the student role thinks about a topic for a given scenario (e.g., what the student understands about equations with variables [25]). After logging in to the Eliciting Learner Knowledge website (i.e., the platform), each member of the pre-service teacher pair receives different information to understand the scenario from their student or teacher perspectives. Next, the two interact remotely through a text-based chat within the website; text is used to focus and simplify the discussion.

More complex digital simulations involve pre-service teachers having verbal discussions with one or more student avatars in a mixed-reality or GenAI simulation. Mixed-reality simulations have been used increasingly over the last 15 years [26, 27]; GenAI simulations are much newer. Mixed-reality simulations involve (a) a human actor playing the role of one or more student avatars and (b) a participant engaging with student avatar(s) who appear on a screen (e.g., through Zoom). The human actor is called an interactor, simulation specialist, or sim; we will use "sim" hereafter. Software platforms for these digital discussions include TeachLivE [28], Mursion® [29], and the Virtual Teaching Simulator [30]. Sims receive extensive platform training to operate the platform, embodying, moving, and voicing the avatars via computer software and hardware. Sims must also prepare to respond as the students according to the scenario. The field is in the early stages of developing, using, and studying simulations in which the avatars are controlled by AI agents instead of a sim [31, 32].

Medical Education

In-person standardized patient simulations have been used in medical education for over 60 years [33, 34], originally and most often as a training tool but also as a research tool. Standardized patients are typically played by human actors [35]. To prepare a standardized patient, simulation designers and implementers provide actors with patient profiles and training. This enables an actor to play the part of a patient with a particular set of symptoms and do so accurately and consistently when interacting repeatedly with multiple participants. The scenario for these simulations includes patient profiles (e.g., describing a patient with upper respiratory symptoms); actor training related to those profiles; and information that the participant (e.g., future nurse or doctor) receives about the patient prior to beginning the simulation. The simulation platform includes the actor and other aspects of the context (e.g., a model hospital room).

Recently, digital platforms have been used so that standardized patients present as avatars on a screen. Some have used mixed reality, enabling nursing students and others to interact with an avatar on a screen who is played by a sim [36, 37]. (Note: We refer to this as "mixed reality" because of the human-in-the-loop sim; the nursing literature also uses "mixed reality" to refer to an integration of virtual and physical interactions.) Others have begun to use generative artificial intelligence (GenAI) platforms like ChatGPT or Tactile VR to respond to participants during a simulation without involvement of a sim [38-41]. In these digital examples, the scenarios include information the participant receives prior to the simulation, as well as the information the sim or GenAI language model needs to implement the simulation.

Research using Digital Discussion-Based Simulations

Examples of digital discussion-based simulation research across medical and teacher education fields include studies about the questions and other prompts participants use during their simulated discussions [42-44], participant experiences in and emotions during simulations [45-47], and the impacts of simulations on participant abilities or beliefs [37, 48-51]. Recent studies have examined the abilities of GenAI to serve as simulation platforms [31, 39, 40]. Finally, a smaller yet important category of simulation research is on the quality of the performance of the actors or sims during simulations [52, 53]. Collectively, these studies have implications for participants' professional learning needs, participants' anticipated abilities to facilitate discussions in real settings, and future simulation development.

A Framework to Develop Digital Discussion-Based Simulation Scenarios for Research

We begin this section by describing two constructs that are important to consider when designing scenarios for digital discussion-based simulations: authenticity and consistency. Following this, we present a framework of scenario design principles that connect to these constructs and focus on digital discussion-based simulations used for research purposes.

Authenticity

Simulations are designed to emulate a real context in some ways and to be unlike a real context in others. Thus, some inauthenticity is intentionally built into simulations since they are approximations of practice, not real practice [54]. This is often done to reduce complexity, i.e., to enable participants to focus on the topic of the simulation (e.g., facilitating a discussion with students about mathematics content) and not be distracted by aspects of a real context that are not pertinent to the topic (e.g., student inattention). Another aspect of inauthenticity in digital discussion-based simulations is that the students are avatars. This is also a benefit in that participants do not have to be concerned about making instructional mistakes with real students.

The focus on the authenticity of a digital discussion-based simulation, then, is on the ways the simulation aims to emulate reality. Authenticity can take three forms: task, avatar interaction, and performance [55]. Task authenticity is about the realness of the task the participant engages in; this use of "task" and our use of "scenario" are interchangeable. Avatar interaction authenticity is about how real the responses of the avatars seem to be during the simulation. Performance authenticity is about how much the participant's performance aligns with what they would do in a real situation. In this paper, we focus on the scenario and avatar response authenticity, two authenticity factors more in our control as scenario designers.

Consistency

Consistency is the idea that multiple repeated enactments of the same simulation—albeit with different participants or multiple iterations with the same participant—will be consistent with respect to avatar responses to similar participant prompts. The idea here is close to the quantitative idea of reliability, yet we avoid using this word given the qualitative nature of digital discussion-based simulations. There are nuances to consistency in mixed reality simulations like Mursion®, described earlier. Part of the way that these simulations feel more authentic is that they are not completely scripted or robotic. The sim responds in real time and directly to the questions posed by the participant. However, this improvisational aspect of the sim's performance as the student avatars has the potential to make their performances less standardized and more variable across participants. This is what Bondie et al. referred to as the standardization versus improvisation challenge for mixed-reality digital discussion-based simulations [26]. Ideally, sims improvise within standardized constraints—dictated by sim scenario materials—to ensure consistency. Staying within those constraints is often referred to as the sim having fidelity. Overall, sim consistency is addressed only somewhat in the literature [52, 53]; more work is needed. Consistency of GenAI simulations also requires further study.

Framework: Scenario Design Principles

Our framework builds upon two resources. One is from the teacher education literature and is about mixed-reality discussion-based simulations [2]. In this work, authors Bondie and Dede focused on the use of these simulations for teacher development (not for research), however, several principles that they identified for scenario design are relevant for research purposes.

These include methods that focus on developing an authentic task such as selecting a student learning dilemma that specific teaching practices impact; aligning the dilemma with standards related to teaching practice and student learning; reviewing the literature about the connection teaching practice and student learning; and, after the scenario is designed, asking real students, teachers, and researchers to review it and provide feedback about its (task) authenticity.

Bondie and Dede suggested methods to support sim accuracy and consistency across participants. These included developing some standard short scripts—perhaps phrases or sentences—for the sim to use during the discussion. This ensures that each participant has reliable opportunities to develop their teaching practice. This kind of short scripting is balanced by a need to make the discussion feel natural, not robotic. Thus, sims are encouraged to improvise within constraints outlined within sim materials (see Principle 8) [26]. Another method to encourage sim accuracy and consistency is to engage sims in practice with feedback (e.g., from scenario authors or other experts) to improve their practice, including to play the complex avatar characters accurately while avoiding reinforcing stereotypes

The other resource from which we draw is from a summary of healthcare simulation standards of best practice for simulation design by the International Nursing Association for Clinical Simulation and Learning (INACSL) [1]. These criteria encompass both technical and discussion-based simulations. Page 15 of this document from INACSL lists the following best practices [1]:

1. [Design] … in consultation with content experts and [simulation experts] … knowledgeable in best practices in simulation education, pedagogy and practice.
2. Perform a needs assessment to provide the foundational evidence of the need for a well-designed simulation-based experience.
3. Construct measurable objectives that build upon the learner’s foundational knowledge.
4. Build the simulation-based experience to align the modality with the objectives.
5. Design a scenario, case, or activity to provide the context for the simulation-based experience.
6. Use various types of fidelity to create the required perception of realism.
7. Plan a learner centered facilitative approach driven by the objectives, learners’ knowledge and level of experience, and the expected outcomes.
8. Create a predebriefing plan that includes preparation materials and briefing to guide participants success in the simulation-based experience.
9. Create a debriefing or feedback session and or a guided reflection exercise to follow the simulation-based experience.
10. Develop a plan for evaluation of the learner and the simulation-based experience.
11. Pilot test simulation-based experiences before full implementation.

Drawing from these resources, we created a novel framework of nine principles for discussion-based scenario design not for training, but rather for research, i.e., for the study of discussions that participants facilitate. These are listed in Table 1. In the table, we connected the principles to their support of task/scenario authenticity, avatar interaction authenticity, and consistency across participants. The first two of these are captured by what the INACSL Committee referred to as the perception of realism in the simulation.

Table 1. Framework: Principles for Discussion-Based Scenario Design for Data Collection

	Principle (with abbreviated title in **bold**)	Supports Task/ Scenario Authenticity	Supports Avatar Interaction Authenticity	Supports Consistency
1.	Identify a simulation **platform**		✓	✓
2.	Identify **research question**(s) to be answered	✓		
3.	Consult with content and simulation **experts** [a,b]	✓	✓	
4.	Draw from **literature** and professional standards [a]	✓		
5.	Identify foundational **knowledge** from which participants can draw [a,b]	✓		
6.	Determine **objectives** for participant engagement [b]	✓		
7.	Develop **participant materials** [a,b]	✓	✓	
8.	Develop **sim materials** [a]	✓	✓	✓
9.	Engage in sim **practice** before implementation [a,b]	✓	✓	✓

[a] These connect to the scenario design steps and features from Bondie and Dede [2]. [b] These connect to criteria from the Healthcare Simulation Standards of Best Practice™ Standards by the INACSL Committee [1].

The first two principles in Table 1 are derived from our broader perspectives on simulation design (Principle 1) and on our translation from training to research (Principle 2). Principle 1 suggest that those who want to use discussion-based scenario design for research purposes first select a simulation platform. This is non-trivial as different platforms present different constraints for subsequent scenario design. Researchers might use the platform developed by the MIT teaching Systems Lab [24, 25], the Mursion® platform that we and others have used [9-11, 13-15, 42-44, 48, 49]; or a GenAI-Based platform [31, 32, 39-41]. These and other platforms have specific features and constraints that need to be considered when authoring scenarios. The selection of the platform also informs how avatars interact with participants and how aspects of those interactions might be designed to ensure consistency across participants.

Principle 2 suggests that research questions—to be answered by the data gathered when participants engage in simulated discussions—are a key aspect of scenario design. Dede and Bondie, who focused on teacher education, discussed identifying a student learning dilemma that aligned with standards for (and literature about) teacher practice or student learning standards [2]. Similarly, the INACSL Committee suggested performing a needs assessment at the early stages of scenario design for medical training. When designing a scenario for research purposes—to study an aspect of real/authentic discussions as they occur for a given situation—research questions are analogous in providing guidance regarding scenario design.

Principles 3 through 10 in Table 1 have direct connections to the scenario design ideas within Bondie and Dede's and/or the INACSL's work [1, 2]. Like scenario design for training, scenario design to support research is supported through consultation and feedback by content and simulation experts (Principle 3) and by consulting the literature (Principle 4). The enactment of both principles informs inform both task/scenario authenticity (e.g., as experts and the literature guide scenario design with respect to the realness of the task). Principle 3 also informs avatar interaction authenticity (e.g., as experts consider scripts or descriptions of how sims respond).

Principle 5 reminds scenario designers that participants come in with prior knowledge from which they can draw during the discussion, again informing task/scenario authenticity.

Principles 6 and 7 focus on the needs for research participants to understand the objectives of the discussion (Principle 6) and to have materials they can use to prepare for and engage in the simulation, including information about the discussion topic and the avatars with whom they will be interacting (Principle 7). Note that we have moved away from the kind of measurable objectives that might be required in a simulation for medical training and towards objectives that guide participant engagement in the discussion; researchers can characterize the ways in which participants met those objectives by analyzing participant discussions. The last two principles focus on the two needs for the sim: (1) sim materials (e.g., avatar background, suggested responses) (Principle 8); and (2) sim practice prior to data collection (Principle 9). Given that the sim is responsible for one side of the discussion across multiple participants, these principles inform task/scenario authenticity, avatar interaction, and consistency.

We pause to note here that it is quite possible that researchers interested in designing a scenario for a discussion-based simulation may start with developing research questions (Principle 2) before selecting a platform (Principle 1). Other principles may be addressed in order different than we have shown in Table 1. For example, consultation with experts (Principle 3) is likely to occur throughout the process, and sim training (Principle 9) might lead to re-development of participant (Principle 7) or sim (Principle 8) materials. We have numbered the principles for easy reference, but do not mean to imply a strict ordering of implementation during scenario design.

Our Example: Iterative Scenario Design within the Discussing Team Conflict Project

Here, we summarize how we implemented the principles within our framework in our Discussing Team Conflict Project. We do so to exemplify the principles within our research context (yet do not intend to provide a full summary of the project or its findings).

Principle 1. Identify a Research Platform

The project team's collaborative work and platform identification began when the first author at Towson University met with engineering design teaching faculty and educational research staff at the University of Delaware. The first author, Lottero-Perdue, demonstrated how Mursion® could be used to support research about how people facilitate difficult discussions under the same constraints. She explained that Towson University had a Mursion® license; she was a trained sim; she had designed scenarios for use with Mursion®; she had conducted research using Mursion®; and although Mursion® had no college-level classroom, Mursion® had a classroom of five high school students that could approximate it (Figure 1).

Figure 1. Mursion® Avatars in the High School Classroom (used with permission)

Principle 2. Identify Research Questions to be Answered

During our initial meeting, we brainstormed research questions related to undergraduate engineering education, broadly, and more specifically to the large (~ 700-student), single-semester, first-year Introduction to Engineering course at the University of Delaware. The course is supported by ~30 near-peer mentors (PMs) each semester. Each PM is an engineering major who completed the course in a prior semester and who was hired and supervised by the faculty course instructor (Malladi) to mentor five teams of five students each. PM responsibilities include meeting weekly with their assigned teams, providing teams with mentoring and guidance, and reviewing the regular submissions of Comprehensive Assessment of Team Member Effectiveness (CATME) peer evaluations that design teams regularly completed [56]. Ultimately, we devised the following research question that guided our scenario design work: *How do PMs facilitate discussions with design teams experiencing engagement-related conflict?*

We use this term, engagement-related conflict, to refer to conflict that occurs when one or more members of a team suspect that other team members are not doing their fair share of the work on a team project. Colloquially, some may refer these individuals as “loafers,” “slackers” or “free riders” [57-59]. We avoid these terms because they suggest that these individuals are not doing their fair share with ill intent or due to laziness. It may be that team members who are perceived to be not doing their fair share may instead, for example, be experiencing marginalization have logistical issues—challenging issues that may be able to be remedied.

Principle 3. Consult with Content and Simulation Experts

Throughout the scenario design process, we both served as and consulted experts. The three co-authors constituted the core team, with experience in: simulation scenario design and Mursion® use for research purposes (Lottero-Perdue); the introductory engineering design course, CATME peer evaluations, and working with PMs (Malladi); and engineering education research (Lottero-Perdue, Malladi, and Headley). Additionally, a prior long-time instructor of the course provided consultation and feedback in our early internally funded scenario design work.

External funding enabled us to create a revised set of scenarios with feedback from an Advisory Board at the University of Delaware but not on the project team. The four-person board had collective expertise in equity, team dynamics, and experiences of diverse students in higher education. A major reason for involving this group was to ensure that our inclusion of marginalized identities on the design team was representative and thoughtful.

Principle 4. Draw from Literature and Professional Standards

We drew from the literature to inform our several aspects of our scenario design process. Early in this development work, the topics we explored in the literature included team conflict [57-61]; research in how teachers facilitate discussion-based simulations [24, 42, 43, 48]; principles of mixed-reality discussion-based simulations [2, 26, 55]; and the affordances and limitations of CATME data (e.g., that reasons for team conflict may not surface from written evaluations) [56]. As mentioned earlier, we were assured by ABET professional standards of the importance of communication within teams and between teams and others (including PMs) [16].

Principle 5. Identify Foundational Knowledge from Which Participants Can Draw

We considered the background knowledge of the PM participants who would be facilitating the discussions as we designed our scenario. As Introduction to Engineering course completers, they had worked on a team like the ones they supervised as a PM, and the team of five students in the Mursion® classroom we used for the study. As former students and current PMs, team conflict—including engagement-related conflict—was familiar to them. Either they or students on other teams they knew or mentored had experienced conflict. PMs were also familiar with the kind of team-based engineering design project that we described in our scenario materials, as well as the assignments and CATME reports students would submit related to the project throughout the semester. Part of the job of a PM was to receive the CATME quantitative scores and qualitative feedback from the teams they supervised and to consider if there was a need to intervene or assist a team as a result. Thus, the preparatory materials that PMs received a part of our scenario included the most recent CATME scores and comments from the fictitious team.

Principle 6. Identify Objectives for Participant Engagement

Ultimately, we created two related scenarios for the PM participants: (1) one-on-one discussions, and (2) a whole-team discussion. PM participants facilitated one-on-one discussions in one data collection session, and the whole-team discussion in a separate data collection session about six weeks later. The objective of the one-on-one discussions for the PMs was to elicit from each team member their perspectives about the team conflict. (Note that PMs facilitated discussions with three of the five avatars, not all five avatars, due to budget constraints and the cognitive demands of the sim and participant during the one-on-one data collection session.) The objective of the whole-team discussion was to see how PMs could help move the team towards resolution (after having the one-on-one discussions). We communicated these objectives to the PM participants (see Principle 7). Also, having these objectives helped us to guide the development of both participant and sim-facing materials, addressed in Principles 7 and 8.

Principle 7. Develop Participant Materials

We created multipage PDF documents for participants to use to prepare for their one-on-one and whole-team discussions, respectively. For the one-on-one discussion, the document included brief descriptions of each student avatar that a PM would likely know by the fifth week in the semester (e.g., Ciara is a civil engineering major and commutes); information about the design project and where the team was in the process; and CATME scores and comments that the team had submitted most recently. For the whole-team discussion, the document included a table of notes that the PM had taken after facilitating the one-on-one discussion (these were not any actual notes taken by the real PMs) and the objective for the discussion. These documents went through an iterative process of refinement as project team members and Advisory Board members reviewed and discussed the scenarios and after sim practice (see Principle 9).

Principle 8. Develop Sim Materials

The sim had access to the participant-facing materials, as well as sim-specific materials that we generated for each scenario (one-on-one and whole-team). These sim materials included avatar backstories that included details about each avatar's interests, families, and the conflicts they experienced on the team (e.g., Ciara was experiencing logistical troubles and Stephanie felt marginalized by the team). These materials also included information about team norms. For each scenario, we generated a sim guidelines document, which included a list of questions PMs might ask and responses that the sim might use in response. These guidelines included short scripts that helped the sim play the student roles consistently during practice and data collection. We also generated a host script for the sim to use to introduce and close each data collection session and to interview the PM participants after each one-on-one or whole-team discussion.

Principle 9. Engage in Sim Practice before Implementation

We developed three participant profiles for project team members to use when facilitating one-on-one and whole-team discussions during multiple sim practice sessions. Profiles included the open-minded listener or the blamer. After each session, the sim and project team member met to discuss how sim performance, participant materials, or sim materials could be improved.

Discussion and Implications

In this paper we have proposed and demonstrated our use of a framework of principles for scenario design for digital discussion-based simulations, building upon ideas about simulation scenario design in the teaching and medical education literature [1, 2] and connecting to key ideas about task or scenario authenticity, avatar interaction authenticity, and consistency [26, 55]. Digital discussion-based simulations are an underutilized and promising tool for engineering education, which values communication as a critical skill [16]. They enable researchers to study how participants communicate in a realistic, yet simplified, simulated environment. This is altogether different than research that explores participants' self-reports about how they have communicated in the past or might communicate in the future. This does not mean that the use of digital discussion-based simulations is without limitations or challenges. These include the cost of some simulation platforms, including Mursion®; participant comfort using the platforms; and the potential for inconsistency of sim performances across participants.

The example we share in this paper from our project uses the Mursion® platform, yet there are others, including GenAI platforms [31, 32, 38-41]. For those interested in pursuing GenAI simulation scenario design, Principles 1 through 7 in Table 1 still apply. Sim materials in Principle 8 would instead include information fed to small language models or prompts to orient the GenAI platform, and sim practice in Principle 9 would be replaced by iterative testing.

We look forward to exploring other ways that discussion-based simulations can be used to support research in engineering education using a variety of digital platforms. This is an area of opportunity for engineering education research. It—and the framework we developed—is also subject to change as technology changes. As the INACSL Committee stated in their simulation standards: "As the science of simulation continues to evolve, so does the need for additions and revisions to the [standards] … Therefore, the[se] standards … are living documents" (p. 14) [1]

Acknowledgements

This material is based upon work supported by the National Science Foundation under Award No. 2407134 and 2407135, as well as from the University of Delaware General University Grant and Towson University Faculty Development & Research Committee Award.

References

[1] INACSL Standards Committee *et al.*, "Healthcare Simulation Standards of Best Practice™ simulation design," *Clinical simulation in nursing,* vol. 58, pp. 14–21, 2021, doi: 10.1016/j.ecns.2021.08.009.

[2] R. Bondie and C. Dede, "Redefining and transforming field experiences in teacher preparation through personalized mixed-reality simulations," in *What teacher educators should have learned from 2020*, R. E. Ferdig and K. E. Pytash Eds.: Association for the Advancement of Computing in Education (AACE), 2021, pp. 229–242.

[3] A. Negahban, "Simulation in engineering education: The transition from physical experimentation to digital immersive simulated environments," *SIMULATION,* vol. 100, no. 7, pp. 695–708, 2024, doi: 10.1177/00375497241229757.

[4] A. C. Szatmary, "Simulation across the mechanical engineering curriculum," in *American Society for Engineering Education Annual Conference and Exposition*, Montreal, Quebec, CA, 2025, doi: 10.18260/1-2—57654.

[5] S. M. Reeves and K. J. Crippen, "Virtual laboratories in undergraduate science and engineering courses: a systematic review, 2009–2019," *Journal of science education and technology,* vol. 30, no. 1, pp. 16–30, 2021, doi: 10.1007/s10956-020-09866-0.

[6] J. Cross, C. Boag-Hodgson, T. Ryley, T. J. Mavin, and L. E. Potter, "Using extended reality in flight simulators: A literature review," *IEEE transactions on visualization and computer graphics,* vol. 29, no. 9, pp. 3961–3975, 2023, doi: 10.1109/TVCG.2022.3173921.

[7] M. Johnson and O. L. de Weck, "Best practices for developing virtual reality education simulations," in *American Society for Engineering Education (ASEE) Annual Conference and Exposition*, Montreal, QC, Canada, 2025, doi: 10.18260/1-2--55502.

[8] P. A. Hebbar, A. A. Pashilkar, and P. Biswas, "Using eye tracking system for aircraft design – a flight simulator study," *Aviation,* vol. 26, no. 1, pp. 11–21, 2022, doi: 10.3846/aviation.2022.16398.

[9] P. S. Lottero-Perdue and J. N. Mikeska, "Simulated Engineering Teaching Experiences: Preservice teachers learning to facilitate discussions to help students become informed designers," in *American Society for Engineering Education Annual Conference and Exposition*, Minneapolis, MN, June 26–29 2022, doi: 10.18260/1-2--41003. [Online]. Available: https://peer.asee.org/41003

[10] P. S. Lottero-Perdue, J. N. Mikeska, and L. Orlandi, "Development and teacher perceptions of an avatar-based performance task for elementary teachers to practice post-testing argumentation discussions in engineering design," in *American Society for Engineering Education Annual Conference and Exposition*, Virtual Online, June 22–26 2020, doi: 10.18260/1-2--34444. [Online]. Available: https://peer.asee.org/34444

[11] P. S. Lottero-Perdue and J. N. Mikeska, "Middle school preservice teachers' discussion prompts to help a student avatar overcome idea fixation during brainstorming," in *American Society for Engineering Education (ASEE) Annual Conference and Exposition*, Montreal, QC, Canada, 2025, doi: 10.18260/1-2–56968. [Online]. Available: https://peer.asee.org/56968

[12] A. S. Jariwala, J. Fennell, and C. Sims, "Communicating effectively with a range of audiences: Audience avatars in engineering design education," in *American Society for*

Engineering Education Annual Conference and Exposition, Portland, Oregon, USA, 2024, doi: 10.18260/1-2--48473.

[13] P. S. Lottero-Perdue, H. Malladi, and M. G. Headley, "Near-Peer Mentors' discussions with a student avatar experiencing logistical Issues on a first-year design team," in *American Society for Engineering Education Annual Conference and Exposition*, Portland, OR, USA, 2024, doi: 10.18260/1-2--47801. [Online]. Available: https://peer.asee.org/47801

[14] H. Malladi, Headley, M.G., Lottero-Perdue, P.S., Buckley, J., "Experienced teaching assistants' perceptions of a simulated environment for facilitating discussions with individual student avatars from a design team in conflict," in *American Society for Engineering Education (ASEE) Annual Conference and Exposition*, Baltimore, MD, 2023, doi: 10.18260/1-2–43545. [Online]. Available: https://peer.asee.org/43545

[15] P. S. Lottero-Perdue, H. Malladi, and M. G. Headley, "Novice versus experienced near-peer mentors' facilitation of a discussion with a student avatar facing logistical challenges on a design team," in *American Society for Engineering Education (ASEE) Annual Conference and Exposition*, Montreal, QC, Canada, 2025, doi: 10.18260/1-2–57005. [Online]. Available: https://peer.asee.org/57005

[16] ABET Engineering Accreditation Commission, "2025-2026 criteria for accrediting engineering programs," Baltimore, MD, 2024. [Online]. Available: https://www.abet.org/wp-content/uploads/2024/11/2025-2026_EAC_Criteria.pdf

[17] F. Fischer and A. Opitz, *Learning to diagnose with simulations : examples from teacher education and medical education*. Cham: Springer Nature, 2022.

[18] D. R. Cruickshank, "The Uses of Simulations in Teacher Preparation: Past, Present, and Future," *Simulation & games,* vol. 19, no. 2, pp. 133–156, 1988, doi: 10.1177/104687818801900202.

[19] A. Benedict-Chambers, S. J. Fick, and A. M. Arias, "Preservice teachers' noticing of instances for revision during rehearsals: A comparison across three university contexts," *Journal of Science Teacher Education,* Article vol. 31, no. 4, pp. 435–459, 2020, doi: 10.1080/1046560X.2020.1715554.

[20] E. Kazemi, H. Ghousseini, A. Cunard, and A. C. Turrou, "Getting inside rehearsals: insights from teacher educators to support work on complex practice," *Journal of Teacher Education,* Report no. 1, p. 18, 2016. [Online]. Available: http://proxy-tu.researchport.umd.edu/login?ins=tu&url=http://search.ebscohost.com/login.aspx?direct=true&db=edsgbc&AN=edsgcl.443549453&site=eds-live&scope=site.

[21] M. Lampert *et al.*, "Keeping it complex: Using rehearsals to support novice teacher learning of ambitious teaching," *Journal of Teacher Education,* vol. 64, no. 3, pp. 226–243, 2013, doi: 10.1177/002248711247383.

[22] H. Masters, "Using teaching rehearsals to prepare preservice teachers for explanation-driven science instruction," *Journal of Science Teacher Education,* Article vol. 31, no. 4, pp. 414–434, 2020, doi: 10.1080/1046560X.2020.1712047.

[23] A. Benedict-Chambers, "Using tools to promote novice teacher noticing of science teaching practices in post-rehearsal discussions," *Teaching and Teacher Education,* Article vol. 59, pp. 28–44, 10/01/October 2016 2016, doi: 10.1016/j.tate.2016.05.009.

[24] M. Thompson *et al.*, "Eliciting Learner Knowledge: Enabling focused practice through an open-source online tool," *Behavioral Sciences,* vol. 12, no. 324, pp. 324–324, 2022, doi: 10.3390/bs12090324.

[25] X. Wang *et al.*, "Practice-based teacher questioning strategy training with ELK: A role-playing simulation for eliciting learner knowledge," in *Proceedings of the ACM on Human-Computer Interaction*, 2021, vol. 5, no. CSCW1, pp. 1–27, doi: https://doi.org/10.1145/3449125.
[26] R. Bondie, Z. Mancenido, and C. Dede, "Interaction principles for digital puppeteering to promote teacher learning," *Journal of Research on Technology in Education,* vol. 53, no. 1, pp. 107–123, 2021, doi: 10.1080/15391523.2020.1823284.
[27] L. Dieker, C. Hughes, and M. Hynes, "The past, the present, and the future of the evolution of mixed reality in teacher education," *Education Sciences,* vol. 13, no. 11, p. 1070, 2023, doi: 10.3390/educsci13111070.
[28] Center for Research in Education Simulation Technology. "TeachLivE: Teaching and Learning in a Virtual Envrionment." University of Central Florida. https://www.ucf.edu/research/research-project/teachlive/ (accessed December 28, 2025).
[29] Mursion. "Our solutions: Transforming workplace interactions—for good." https://www.mursion.com/solutions/ (accessed December 28, 2025).
[30] Institute for Digital Intermedia Arts. "NSF Virtual Teaching Simulator." Ball State University. https://idialab.org/nsf-virtual-teaching-simulator/ (accessed December 28, 2025).
[31] S. Hong, J. Moon, T. Eom, I. D. Awoyemi, and J. Hwang, "Generative AI-enhanced virtual reality simulation for pre-service teacher education: A mixed-methods analysis of usability and instructional utility for course integration," *Education sciences,* vol. 15, no. 8, p. 997, 2025, doi: 10.3390/educsci15080997.
[32] Y. Zhuang and S. Zhang, "Integrating ChatGPT in mathematics teacher education: Ai-based simulation role-playing to support practice-based teaching," *International journal of artificial intelligence in education,* vol. 35, no. 6, pp. 3873–3895, 2025, doi: 10.1007/s40593-025-00519-0.
[33] H. S. Barrows and S. Abrahamson, "The programmed patient: A technique for appraising student performance in clinical neurology," *J Med Educ,* vol. 39, pp. 802–5, Aug 1964. [Online]. Available: https://www.ncbi.nlm.nih.gov/pubmed/14180699.
[34] H. S. Barrows, "An overview of the uses of standardized patients for teaching and evaluating clinical skills.," *Academic Medicine,* vol. 68, no. 6, pp. 443–451, 1993.
[35] S. Simmons, M. Tabi, E. Bester, and J. Zanetos, "Integrating telehealth into nursing education through standardized patient simulation," *Clinical simulation in nursing,* vol. 97, p. 101647, 2024, doi: 10.1016/j.ecns.2024.101647.
[36] A. Perez, K. Gaehle, B. Sobczak, and K. Stein, "Virtual simulation as a learning tool for teaching graduate nursing students to manage difficult conversations," *Clinical simulation in nursing,* vol. 62, pp. 66–72, 2022, doi: 10.1016/j.ecns.2021.10.003.
[37] L. A. Taliaferro, N. J. Westers, B. Matsumiya, K. Ingraham, J. J. Muehlenkamp, and C. E. Hughes, "Improving capacity to identify, assess, and manage adolescents engaging in non-suicidal self-injury using patient avatars," *Medical teacher,* vol. 45, no. 11, pp. 1283–1289, 2023, doi: 10.1080/0142159X.2023.2216861.
[38] J. M. Reed, M. Aebersold, and K. Lasater, "From noticing to clinical judgment: Exploring anxiety in virtual reality nursing simulation," *Nurse educator,* vol. 51, no. 1, pp. 35–40, 2026, doi: 10.1097/NNE.0000000000002008.

[39] J. Cross *et al.*, "Assessing ChatGPT's capability as a new age standardized patient: Qualitative study," *JMIR Med Educ,* vol. 11, p. e63353, May 20 2025, doi: 10.2196/63353.
[40] C. Wang *et al.*, "Application of large language models in medical training evaluation-using chatgpt as a standardized patient: Multimetric assessment," *J Med Internet Res,* vol. 27, p. e59435, Jan 1 2025, doi: 10.2196/59435.
[41] K. Sepanloo, D. Shevelev, M. T. Islam, Y.-J. Son, S. Aras, and J. E. Hinton, "Improving nursing education through an AI-enhanced mixed reality training platform: development and pilot evaluation," *Educational technology research and development,* vol. 73, no. 3, pp. 1835–1863, 2025, doi: 10.1007/s11423-025-10473-2.
[42] H. L. Masters, P. S. Lottero-Perdue, N. Placa, E. Galindo, J. N. Mikeska, and H. Howell, "Elementary preservice teachers' use of prompts to encourage student-to-student talk during simulated argumentation discussions," *School Science and Mathematics,* 2024, doi: 10.1111/ssm.12685.
[43] J. N. Mikeska and H. Howell, "Simulations as practice-based spaces to support elementary teachers in learning how to facilitate argumentation-focused science discussions," *Journal of Research in Science Teaching,* vol. 57, no. 9, pp. 1356–1399, 2020, doi: 10.1002/tea.21659.
[44] J. N. Mikeska, P. S. Lottero-Perdue, D. Brockway, A. Finnegan, and J. Steinberg, "Using digital simulated classrooms to examine elementary teachers' ability to engage students in scientific argumentation," presented at the NARST Annual International Conference, Portland, OR [Conference cancelled], 2020. [Online]. Available: https://narst.org/sites/default/files/2020-04/NARST%202020%20Conference%20Program%20Book%20with%20URLs.pdf.
[45] R. H. Najjar, B. Lyman, and N. Miehl, "Nursing students' experiences with high-fidelity simulation," *International Journal of Nursing Education Scholarship,* vol. 12, no. 1, pp. 27–35, 2015, doi: 10.1515/ijnes-2015-0010.
[46] D. R. Davis, A. Noltemeyer, D. Roberts, C. Rode, and E. Barth, "Physiological stress response to challenging classroom behavior," *The Journal of classroom interaction,* vol. 55, no. 2, pp. 34–50, 2020.
[47] V. Salo, P. Rikala, K. Vähäsantanen, and R. Hämäläinen, "Emotions in nursing students' simulations: A qualitative case study," *Clinical simulation in nursing,* vol. 101, p. 101701, 2025, doi: 10.1016/j.ecns.2025.101701.
[48] J. N. Mikeska, H. Howell, and D. Kinsey, "Do simulated teaching experiences impact elementary preservice teachers' ability to facilitate argumentation-focused discussions in mathematics and science?," *Journal of Teacher Education,* vol. 74, no. 5, pp. 422–436, 2023, doi: 10.1177/00224871221142.
[49] J. N. Mikeska, H. Howell, and C. Straub, "Using performance tasks within simulated environments to assess teachers' ability to engage in coordinated, accumulated, and dynamic (CAD) competencies," *International Journal of Testing,* vol. 19, no. 2, pp. 128–147, 2019, doi: 10.1080/15305058.2018.1551223.
[50] N. U. Bautista and W. J. Boone, "Exploring the impact of TeachME™ lab virtual classroom teaching simulation on early childhood education majors' self-efficacy beliefs," *Journal of Science Teacher Education,* vol. 26, no. 3, pp. 237–262, 2015, doi: 10.1007/s10972-014-9418-8.

[51] M. S. Taylor, Tucker, J., Donehower, C., Pabian, P., Dieker, L. A., Hynes, M. C., & Hughes, C. , "Impact of virtual simulation on the interprofessional communication skills of physical therapy students: A pilot study," *Journal of Physical Therapy Education,* vol. 31, no. 3, pp. 83–90, 2017, doi: 10.1097/00001416-201731030-00015.
[52] L. A. H. Erby, D. L. Roter, and B. B. Biesecker, "Examination of standardized patient performance: Accuracy and consistency of six standardized patients over time," *Patient education and counseling,* vol. 85, no. 2, pp. 194–200, 2011, doi: 10.1016/j.pec.2010.10.005.
[53] P. Mello and D. van der Merwe, "Maintaining fidelity in mixed reality simulation: Insights from simulation specialists at a South African university," *South African Journal of Childhood Education,* vol. 16, no. 1, pp. e1–e11, 2026, doi: 10.4102/sajce.v16i1.1816.
[54] P. L. Grossman, *Teaching core practices in teacher education*. Harvard Education Press, 2018.
[55] J. N. Mikeska and H. Howell, "Authenticity perceptions in virtual environments," *Information and learning science,* vol. 122, no. 7/8, pp. 480–502, 2021, doi: 10.1108/ILS-10-2020-0234.
[56] M. W. Ohland *et al.*, "Developing a peer evaluation instrument that Is simple, reliable, and valid," in *American Society for Engineering Education Annual Conference and Exposition*, Portland, OR, 2005, pp. 10.430.1 – 10.430.5, doi: 10.18260/1-2--14413.
[57] M. Borrego, J. Karlin, L. D. McNair, and K. Beddoes, "Team Effectiveness Theory from industrial and organizational psychology applied to engineering student project teams: A research review," *Journal of Engineering Education,* vol. 102, no. 4, pp. 472–512, 2013/10/01 2013, doi: 10.1002/jee.20023.
[58] C. Gabelica, S. De Maeyer, and M. C. Schippers, "Taking a free ride: How team learning affects social loafing," *Journal of Educational Psychology,* 2021, doi: 10.1037/edu0000713.
[59] S. J. Karau and K. D. Williams, "Social loafing: A meta-analytic review and theoretical integration," *Journal of Personality and Social Psychology,* vol. 65, no. 4, pp. 681–706, 1993, doi: 10.1037/0022-3514.65.4.681.
[60] J. Buckley, A. Trauth, S. B. Grajeda, and D. Roberts, "Gender and racial disparities in students' self-confidence on team-based engineering design projects," in *ASEE Annual Conference & Exposition*, Tampa, FL, 2019, doi: 10.18260/1-2--32869.
[61] B. Linder, M. Somerville, Ö. Eris, and N. Tatar, "Taking one for the team: Goal orientation and gender-correlated task division," in *ASEE/IEEE Frontiers in Education Conference*, Washington, DC, 2010, pp. p. F4H–1.