Cyberlearning: The Role of Agency and Interactivity for Virtual Training of Teachers in High Poverty Schools

Proposal in Response to
Program Announcement NSF 19-589

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2020-10-30

Project Summary

Overview. The aim of this proposal is to systematically study the impact of embodied conversational agents on learning outcomes of teachers in high poverty schools, where rates of disruptive behaviors are three times national estimates and where teacher stress and turnover is empirically linked to disruptive behaviors.

Developing teachers' knowledge and skills in responding effectively to student disruptive behaviors is a critical professional development goal given the empirical link between effective behavior management and student learning and achievement and high rates of turnover among teachers working in high poverty schools. Virtual Reality platforms for teacher training leverage important pedagogical strengths (e.g., realistic training context, opportunities for practice and feedback, low-stakes training) that may confer advantages over traditional training for teachers in behavior management for which didactic strategies (e.g., presentation, demonstration, discussion) pervade despite research suggesting active learning (e.g., practice, reflection, and feedback) as critical to teacher skill acquisition and transfer.

Traditional training for teachers in behavior management (e.g., workshops, whole group inservice training) has failed to produce substantial improvements in teachers' work-related knowledge and skills. Although several simulation training platforms focused on developing teachers' instructional and behavior management skills are emerging, existing research suggests these platforms suffer from low usability and limited realism particularly when simulated conversations are embedded into the models.

In our current work, we have developed an interactive virtual training platform in which teachers can engage with first and sixth grade students in a virtual classroom using pre-scripted challenging interactions. Our preliminary studies indicate that although the scenarios and graphics are compelling, the forced response option format is restrictive because available response options do not represent how trainees would respond to disruptive behavior and preference for trainees generating their own responses to characters rather than the system generating it.

As part of the proposed research activities, we will develop a virtual training platform which supports intelligent virtual avatars (virtual students) which can engage, and freely interact with teachers, while conforming to the specified guidelines of the training narratives. The proposed intelligent virtual avatars will be: *autonomous*, *embodied*, *expressive*, and *conversational*, and be able to intelligently engage in multi-modal conversations with the teacher in a responsive manner, while expressing their intentions using verbal and non-verbal responses (e.g., facial expressions, hand and body gestures etc). These technological advancements will facilitate non-linear, free-form interactions between teachers and (virtual) students, beyond linear, pre-scripted experiences possible in existing training tools. These free-form interactions are theorized to support transfer of learning from one setting (e.g., virtual classroom) to a new setting (e.g., live classroom), where teachers may carry forward applicable knowledge and skills learned in a virtual classroom, when confronted with similar situations in a real setting. We will conduct a series of studies over a 3-year time period, where we will systematically study the impact of agency and interactivity in virtual training platforms on the training outcomes of teachers, and their ability to transfer knowledge and skills to real classrooms.

Intellectual Merit. As the achievement gap widens, there is a pressing need for teachers working in disadvantaged schools where students are at greatest risk for academic failure to develop their behavior management skills in a safe, low-consequence-for-failure environment. Adding agency and interactivity to the current VR training model is theorized to create a more dynamic, engaging, effective training system that supports transfer of learning from one setting (e.g., virtual classroom) to a new setting (e.g., live classroom). This type of training in behavior management provides an unprecedented opportunity to augment existing support to teachers and foster the dissemination and implementation of effective training that can enhance student achievement and well-being.

Broader Impact. Teachers in high poverty schools face of overwhelming challenges managing disruptive behaviors with studies highlighting that behavior problems as one of the most robust predictors of turnover. Virtual Reality-based training provides an unprecedented opportunity for teachers to practice responding to disruptive behaviors with the freedom to explore and fail in a low-stakes setting. This is in contrast to the traditional trial-and-error approach which becomes extremely costly with our most vulnerable learners.

Keywords. Virtual Training Platforms, Teacher Training, High Poverty Schools, Embodied Conversational Agents, Intelligent Virtual Agents,

1 Introduction

Aims and Objectives. The aim of this proposal is to systematically study the impact of embodied conversational agents on learning outcomes of teachers in high poverty schools, where rates of disruptive behaviors are three times national estimates and where teacher stress and turnover is empirically linked to disruptive behaviors [35, 53, 91].

Challenges. Developing teachers' knowledge and skills in responding effectively to student disruptive behaviors is a critical professional development goal given the empirical link between effective behavior management and student learning and achievement and high rates of turnover among teachers working in high poverty schools [45]. Virtual Reality platforms for teacher training leverages important pedagogical strengths (e.g., realistic training context, opportunities for practice and feedback, low-stakes training) that confer advantages over traditional training for teachers in behavior management for which for which didactic strategies (e.g., presentation, demonstration, discussion) pervade despite research suggesting active learning (e.g., practice, reflection, and feedback) as critical to teacher skill acquisition and transfer [22, 74, 78].

Traditional training for teachers in behavior management (e.g., workshops, whole group inservice training) has failed to produce substantial improvements in teachers' work-related knowledge and skills [60]. Although several simulation training platforms focused on developing teachers' instructional and behavior management skills are emerging, existing research suggests these platforms suffer from low usability and limited realism particularly when simulated conversations are embedded into the models [5, 64].

In our current work, we have developed an interactive virtual training platform in which teachers can engage with first and sixth grade students in a virtual classroom using pre-scripted challenging interactions. Our preliminary studies indicate that although the scenarios and graphics are compelling, the forced response option format is restrictive because available response options do not represent how teachers would respond to disruptive behavior and preference for teacher generating their own responses to characters rather than the system generating it.

Proposed Research. As part of the proposed research activities, we will develop a virtual training platform which supports intelligent virtual avatars (virtual students) which can engage, and freely interact with teachers, while conforming to the specified guidelines of the training narratives. The proposed intelligent virtual avatars will be: *autonomous*, *embodied*, *expressive*, and *conversational*, and be able to intelligently engage in multi-modal conversations with the teacher in a responsive manner, while expressing their intentions using verbal and non-verbal responses (facial expressions, hand and body gestures etc). These technological advancements will facilitate non-linear, free-from interactions between teachers and (virtual) students, beyond linear, pre-scripted experiences possible in existing training tools. These free-form interactions are theorized to support transfer of learning from one setting (e.g., virtual classroom) to a new setting (e.g., live classroom), where learners may carry forward applicable knowledge and skills learned in a virtual classroom, when confronted with similar situations in a real setting.

We will systematically study platform usability (years 1 and 2) in addition to the impact of different platform conditions on proximal teacher outcomes (knowledge and skill transfer; years 2-3) and more distal outcomes (e.g., student achievement and behavior) in year 3. Specifically, we will study the influence of: (a) agency in virtual students (pre-scripted vs. interactive agents), (b) mode of interaction (discrete choice selection vs. conversational), and (c) level of expressivity in virtual students (presence or absence of facial expressions and hand, body gestures) on proximal teacher outcomes (efficacy in teaching), as well as more distal outcomes (student achievement).

For the year 2 feasibility study, we will assess knowledge and skill transfer with a sample of K-6 teachers working in one urban district who meets our inclusion criteria (70% or more of students qualifying for free or reduced lunch; see see letter of collaboration). The sample for the usability studies include n = 36 (years 1-2), feasibility study n = 40 (year 2). The randomized controlled trial (year 3) includes teachers (n=25 per condition; N=75) and K-8 students at risk for behavioral problems (n=68 per condition; N=136). Years of experience, comfort with technology, and grade level will be used as controls in our study. Measures include: (1) observations of student behavior and engagement; (2) observation and teacher-reported use of behavior management skills taught; (3) teacher-reported student behavioral competence; and (4) student measures of achievement.

Intellectual Merit. The proposed research activities will concurrently advance our technology goals, together with our learning and educational goals.

Technology Goals. A key deliverable of this proposal is the development, deployment, and evaluation of a virtual training platform where teachers can fully immerse themselves in virtual classrooms and engage with fully realized, autonomous virtual students which can express themselves using facial expressions, hand and body gestures, and spoken language, using a conversational interface. These significant advancements will push the boundaries of agency and interactivity in virtual reality training platforms.

Learning and Education Goals. As the achievement gap widens, there is a pressing need for teachers working in disadvantaged schools where students are at greatest risk for academic failure to develop their behavior management skills in a safe, low-consequence-for-failure environment. Adding agency and interactivity to the current VR training model is theorized to create a more dynamic, engaging, effective training system that supports transfer of learning from one setting (e.g., virtual classroom) to a new setting (e.g., live classroom). This type of training in behavior management provides an unprecedented opportunity to augment existing support to teachers and foster the dissemination and implementation of effective services that can enhance student achievement and well being [4]. Additionally, it promotes the scale up of technological advancements in high poverty schools.

Broader Impact. Teachers in high poverty schools face of overwhelming challenges managing disruptive behaviors with studies highlighting that behavior problems as one of the most robust predictors of turnover [34]. Virtual Reality-based training provides an unprecedented opportunity for teachers to practice responding to disruptive behaviors with the freedom to explore and fail in a low-stakes setting. This is in contrast to the traditional trial-and-error approach which becomes extremely costly with our most vulnerable learners.

PI Qualifications. PI Kapadia is an Assistant Professor and the Director of the Intelligent Visual Interfaces Lab in the Computer Science Department at Rutgers University. Kapadia's research focuses on developing intelligent visual interfaces to foster learning and creativity. Kapadia's research is supported through grants from NSF and DARPA. Kapadia has experience in Artificial Intelligence, Humanoid Character Animation, and Natural Language Understanding, and has developed solutions for animating autonomous virtual avatars [26, 40, 80], and embodied conversational agents [14, 15, 27, 36, 85, 98] , which will be used as a foundation for the proposed technological advancements to the virtual training platform.

Co-PI Elisa S. Shernoff is an Associate Professor and Program Director of the School Psychology Program. Dr. Shernoff's program of research is designed to: (1) leverage technology to enhance teacher training and support in high poverty schools, and (2) examine models of training, support, and supervision to maximize high quality instruction. Since 2009, she has secured continuous federal funding from the US Department of Education along with private foundations, including the Brady Education Foundation. She has developed expertise in developing and evaluating the effectiveness of virtual training platforms with a specific emphasis on embedding instructional design principles that are empirically linked to learning and transfer.

2 Background including Technological State-of-the-Art

Traditional training for teachers in behavior management (e.g., workshops, whole group inservice training) has failed to produce substantial improvements in teachers' work-related knowledge and skills [60]. Technology-based interactive training models designed to improve teachers' behavior management skills leverage critical pedagogical advantages related to practice, reflection and feedback while solving authentic work-based scenarios and problems [28, 74, 76]. Such models also address inherent weaknesses to traditional training in behavior management [60, 74].

Virtual Training Platforms for Teacher Training. Virtual Training confers important instructional design advantages over traditional professional development for teachers in behavior management. First, these platforms build on studies highlighting that learning and transfer is enhanced when realistic work scenarios are portrayed and when users have to make decisions relevant to their work performance [82, 89]. Second, they provide opportunities for extended practice that is paired with feedback to enhance teachers knowledge and skills in effective instruction. These instructional design elements contrast with traditional training for teachers in behavior management for which presentation, demonstration, discussion pervades despite research establishing active learning strategies (e.g., practice, reflection, and feedback) as critical to teacher skill acquisition and transfer [22, 76, 78]. Third, Virtual training provides a low-stakes training environment in which teachers are free to explore challenging interactions with students and make decisions about how to respond in a safe, low-consequence-for-failure environment [74]. This becomes crucial in high poverty schools, where repeated mistakes related to behavior management can have a negative impact on our most vulnerable learners [4]. Finally, Virtual Training, in contrast to in-person coaching, provides an unprecedented opportunity for teachers to access instructional support [72] that is fully sustainable because of the web-based platform designed for teachers to use with their existing computing systems.

Virtual Training Platforms have been used in education domains such as Construction [95], Chemical Engineering [57], and Robotics [21]. They have also been used to train Teachers in necessary classroom skills to support students such as social skills [7], presence, and empathy [87]. Several platforms related to behavior management have been developed, including TeachLivE [24], simSchool [5]. These models are growing in popularity but rigorous evaluations of their efficacy remain limited. Early feasibility work on simSchool [5] indicates limited evidence of educational utility and low usability ratings [64]. Quasi-experimental designs evaluating TeachLivE indicate promising findings related to teachers' development of instructional and behavior management skills [24] along with users rating the system as realistic and compelling [23]. However, its mixed-reality training requires high-end equipment, which may limit its reach.

Conceptual Framework. Experiential learning theory [43, 48] emphasizes ongoing practice as critical for knowledge and skill transfer and posits that mastery develops via concrete, physical learning opportunities in authentic learning contexts. Technology-based training allows teachers to systematically acquire and master a small set of practices at a comfortable pace, with feedback, in a low-stakes environment. Although several training platforms focused on developing teachers' instructional and behavior management skills are emerging, existing research suggests some of these platforms may suffer from low usability and limited realism particularly when simulated conversations are embedded into the models [5, 64].

Intelligent Virtual Agents. Recent advancements in intelligent virtual agents (IVA's) have increased their applicability in a variety of discplines including training applications. Scientists have explored methods to increase engagement with experiments in social priming [19], multimodal rapport building [51], agent's person perception [88], multimodal conversation [99], compatible conversational-styles [73], and using rapport vs trusting language [1]. Scientists have engaged in research to give IVAs culture appropriate behaviors [50], Visual embodiment [42], situational non-verbal cues [32], and physical and social presences [90]. These and many other experiments have allowed for researchers to develop frameworks and environments for the purposes of testing IVAs. These frameworks are used to develop IVAs for an AR environment [2], rapid development of IVAs [30], a collaboration simulation of IVA-Human Hybrid Teams [3], HCI-based IVA [31], and IVA for explainable AI [97].

Embodied Conversational Agents (ECA) enhance traditional IVA capabilities beyond verbal interactions by introducing other modalities where ECA's are able to leverage facial expressions, and gestures when interacting with users [42]. Scientists have explored how ECAs can use visual cues paired with vocal cues to be perceived as agents with personality [12], or agents with a sense of intimacy [61]. The reactions to visual and vocal cues are also regularly analyzed as personalized feedback from an ECA can increase adherence [62] and presentation can increase knowledge recall [47]. ECAs are also used to affect certain outcomes often only found in human-to-human interactions such as inducing rapport building [55] or creating a learning environment for tutors with predefined learning goals [54].

PI's Current and Preliminary Work. Co-PI Shernoff has developed an interactive virtual training platform [74, 76, 79] where teachers can engage with first and sixth grade students in a virtual classroom with pre-scripted challenging interactions. Preliminary studies of the existing platform indicate that the scenarios and graphics are compelling and realistic [74] and that the system has strong usability and novel

Study	Platform Conditions	Users	Experiment Timeline	Research Question	Dependent Measures	Analyses
Thrust 2: Usability Studies	Condition A	Preservice teachers (n=12)	4/21 - 7/21	To evaluate usability of each platform condition	(1) System Usability Scale (SUS); (2) Questionairre for User Satisfaction (QUIS); (3) Concurrent Think Aloud Protocols (CTA)	Review CTA transcripts, screen captures and video recordings to summarize the number of benchmark tasks completed, time required to complete each task, number of errors encountered, and percentage of users meeting each learning objective during the formative evaluation sessions. Numeric usability ratings will provide the team with an initial indication of user attitudes toward the system given learnability, system functionality, and ease of use. Identify predominant usability issues and reach consensus on user benefits associated with each re-design recommendation (1 = Very Low Benefit to 4 = Very High Benefit). Rate the cost in time and resources associated with each recommendation (1 = Very Low Cost to 4 = Very High Cost). Calculate a cost/benefit ratio for each re-design recommendation, prioritizing low cost/high benefit revisions and coming to consensus on revisions with equal costs and benefits.
	Condition B	Preservice teachers (n=12)	9/21 - 12/21			
	Condition C	Preservice teachers (n=12)	6/22 - 9/22			
Thrust 3: Feasibility Studies	Condition A	Teachers (n=20)	12/21 - 4/22	To assess usage platform by teachers, teacher knowledge and skill transfer	(1) Usage Measures; (2) Teacher Knowledge of Evidence-Based Practices; (3) Teaching Strategies Questionairre (TSQ); (4) Classroom Practices Questionairre (CPQ)	Two level linear mixed-effects models will be specified using data collected on the sample of teachers at two time points.Our primary interest is in the slope parameter to examine the changes in teachers knowledge and skills in behavior management over time. Close monitoring of the tracking logs will assess utilization of the system as designed. Associations between dosage and knowledge and skill transfer will inform a threshold for dosage during the final year.
	Condition B	Teachers (n=20)	12/21 - 4/22			
Thrust 4: Randomized Controlled Trial	Condition A	Teachers from schools who meet inclusion criteria (n=25); Students (n=75-100)	11/22 - 4/23	To evaluate the role of character agency and teacher interactivity on teacher engagement, skill development, and student behavior	(1)Usage, Knowledge Transfer, and Skill Transfer Measures listed above; (2) Classroom Strategies Assessment System (CSAS); (3) Student Outcomes using Problem Behavior Subscale of the Social Skills Improvement System (SSIS); (4) Student reading and math achievement	Three level mixed-effects regression models will compare outcomes between conditions, with time points (level 1) nested within students (level 2) and students nested within teachers (level 3). Variability at the teacher and student levels will be modeled using the random intercept and random slope. Our primary interest is in the slope parameter to examine the changes in teachers knowledge and skills in behavior management over time and changes in student learning and behavior over time. For teacher-level outcomes, prior gaming experience at baseline and teacher demographics will be included as covariates.
	Condition B	Teachers from schools who meet inclusion criteria (n=25); Students (n=75-100)	11/22 - 4/23			
	Condition C	Teachers from schools who meet inclusion criteria (n=25); Students (n=75-100)	11/22 - 4/23			

Table 1: Outline of research plan for learning and education goals, including research questions, research design, measures, and analyses.

instructional design features [79] but the forced response format does not fully represent how teachers would respond to disruptive behaviors with users indicating a strong preference for generating their own responses [79]. Furthermore, users indicated that the pre-programmed avatar responses contributed to a repetitive training experience and that unpredictable reactions from the avatars would increase their engagement and motivation to use the system [79].

PI Kapadia has extensive experience in developing platforms for animating autonomous virtual avatars [26, 40, 80], and embodied conversational agents [14, 15, 27, 36, 85, 98] , which will be used as a foundation for the proposed technological advancements to the virtual training platform.

The Importance of Agency in Virtual Training Platforms. Usability studies [79] indicated that the forced response option was restrictive. Some users indicated that the available response options did not represent how they would respond to disruptive behavior either because the options didn't fit (e.g., "I would have approached him [the character] and told him what to do"), because it was difficult to select from the available choices (e.g., "... selecting one response option was difficult") because they wanted to generate their own responses rather than selecting the system generated option (e.g, "I would not do any of these things") or because they wanted to combine across responses "The hardest part, for me, was wanting to combine two answer choices." Other users indicated that the fixed response options forced them to avoid ineffective responses and select the obvious effective responses to perform well in the system and that the forced decision points left them wondering how the character would have responded had they selected a bad choice.

3 Proposed Research

Figure 1 illustrates the proposed research activities which advances our technology goals, concurrently with our learning and education goals, and are divided in the following main research thrusts. Thrust 1 describes the incremental development of a virtual training platform for teachers which supports embodied conversational avatars and free-form user interaction. Thrust 2 describes usability studies to assess the usability of different versions of the training platform. Thrust 3 describes a series of feasibility studies to assess if the platform variants are used as intended, and whether there are any reported increases in knowledge and skill transfer in teachers using the platform. Our research culminates in a randomized controlled trial (Thrust 4) which systematically evaluates the role of character agency and teacher interactivity on teacher training outcomes and student behavior outcomes.

Subject Recruitment. One medium sized high poverty school district will partner with the investigative

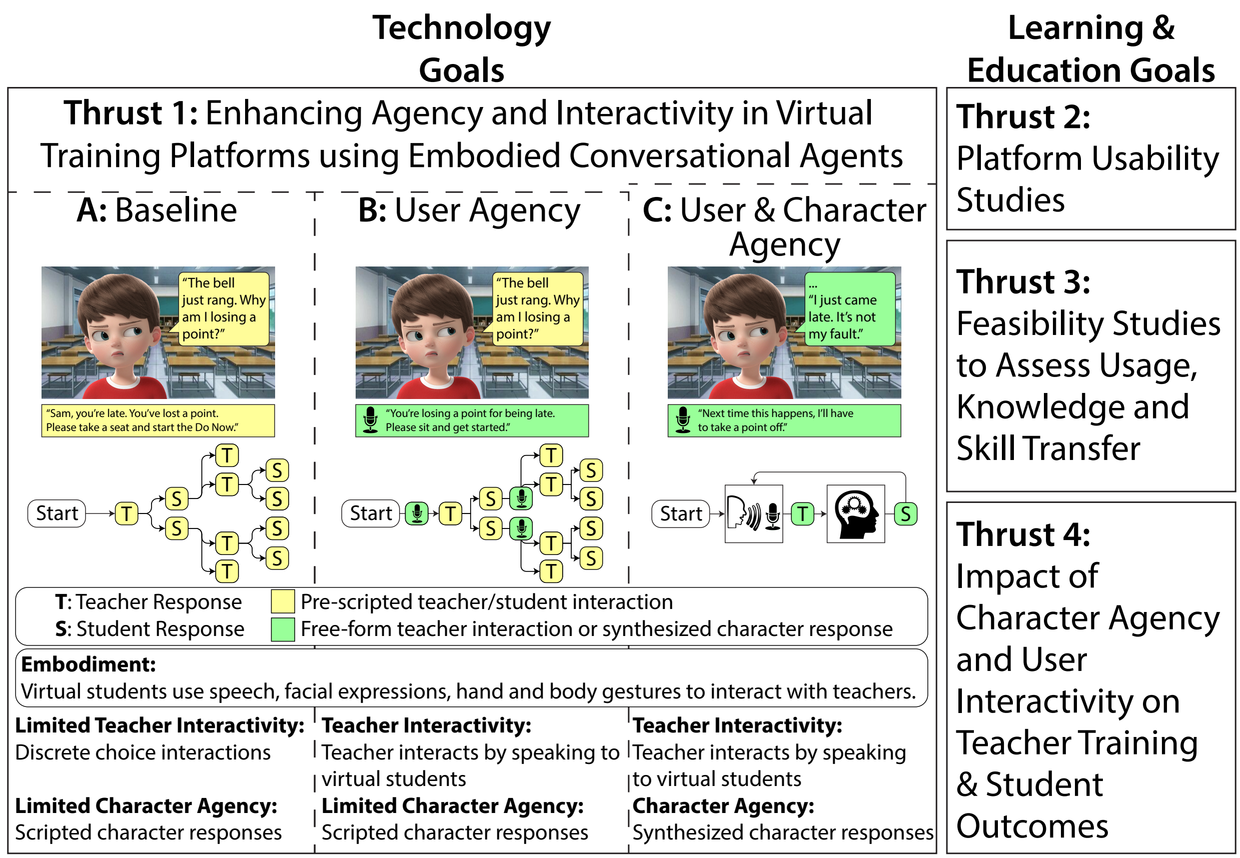

Fig. 1: Summary of Proposed Research Activities. The baseline platform (A) offers pre-authored choices (yellow) to the teacher. Condition B accepts free-form inputs (green) from the teacher. Both conditions return scripted agent dialogue, while Condition C showcases free-form inputs (green) from the teacher and character agency (green), resulting in unique teacher-student interactions.

team to complete the feasibility study (Year 2, Thrust 3) and final study (Year 3, Thrust 4). This school district serves more than 10,000 students across 22 campuses, including students from preschool through 12th grade. This district has 22 schools characterized as 93% African American, 6% Latinx, and 1% European American. Eighty seven percent of students are eligible for free or reduced lunch in 2017-2018. We expect strong participation from the school district and schools as Co-PI Shernoff has developed a strong collaboration with this district via an ongoing federally funded grant. Co-PI Shernoff has been very successful involving teachers in prior research, obtaining consent rates of over 90% in several successive studies in high poverty schools [74–76].

IRB Approval. Rutgers, The State University of New Jersey, adheres to all federal regulations pertaining to studies involving human subjects. An Institutional Review Board oversees compliance with regulations for individual investigators. Given the proposed timeline, we will begin preparing necessary consents and recruitment materials and expect to be able to obtain IRB approval for the proposed work and adhere to the proposed timeline for recruitment and consent for participating teachers. Co-PI Shernoff has extensive experience obtaining IRB approval (exempt, expedited and full review) over the past 15 years in which she has been conducting school-based research in high poverty schools.

Thrust 1: Enhancing Agency and Interactivity in Virtual Training Platforms using Embodied Conversational Agents

As part of this research, we will advance the capabilities of the existing platform developed by Co-PI Shernoff to support intelligent virtual avatars for virtual students which can engage, and freely interact with teachers, while conforming to the specified guidelines of the training narrative. The proposed intelligent

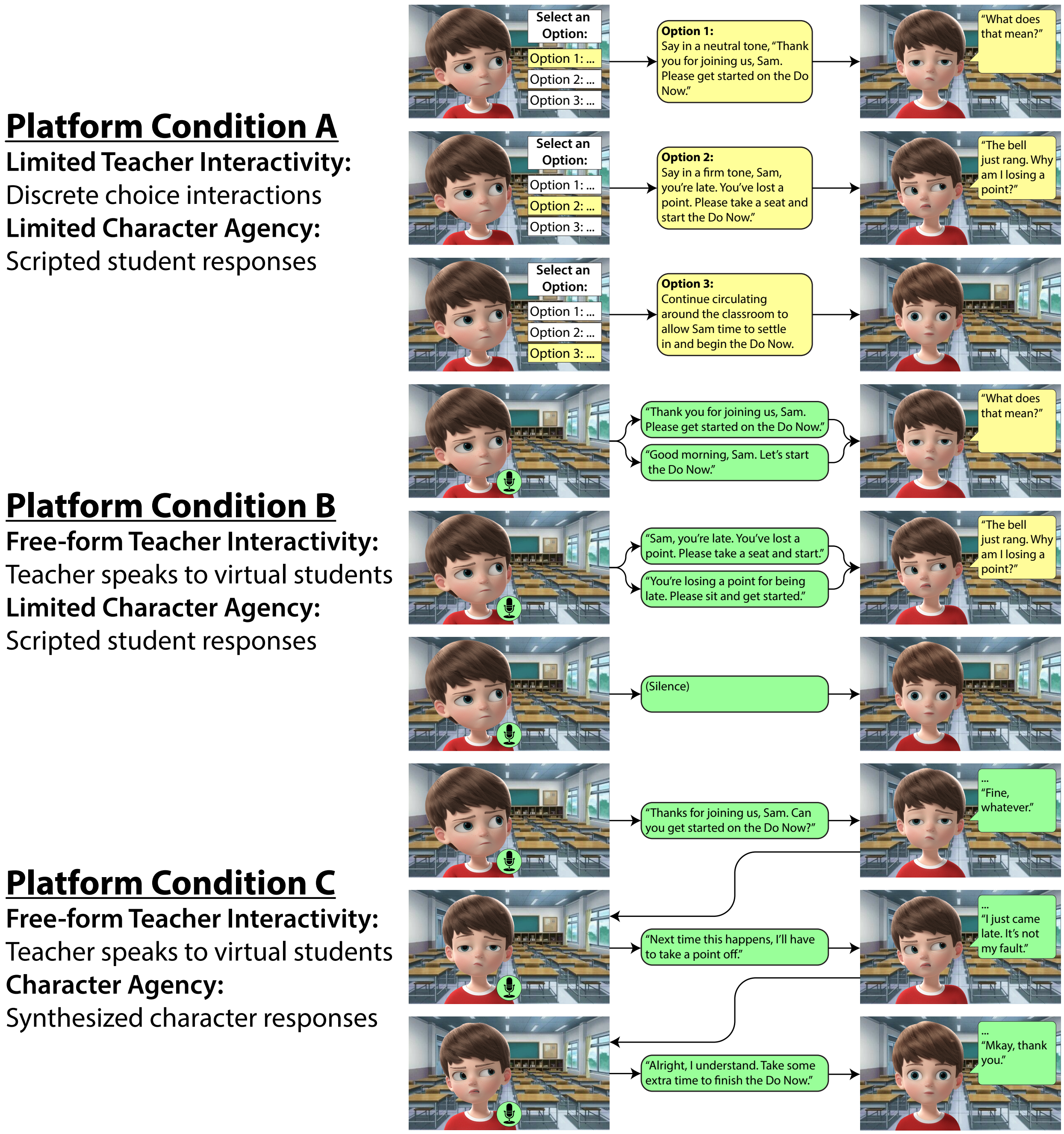

Fig. 2: Anticipated teacher experience when using each of the 3 platform conditions. Platform A (baseline) offers pre-authored choices (yellow) to the teacher, and scripted student response. Platform B allows the teacher to speak to student, with scripted student responses. Platform C facilitates free-form teacher interaction, where the teacher can speak to the student, and the virtual student is able to synthesize responses to unanticipated teacher input.

virtual avatars will be: autonomous, embodied, expressive, and conversational, and be able to intelligently engage in multi-modal conversations with the teacher in a responsive manner, while expressing their intentions using verbal and non-verbal responses (e.g., facial expressions, hand and body gestures etc). These technological advancements will facilitate non-linear, free-form interactions between teachers and (virtual) students, beyond linear, pre-scripted experiences possible in existing training tools. These free-form interactions are theorized to support transfer of learning from one setting (e.g., virtual classroom) to a new setting (e.g., live classroom) if trainees confront similar situations and can carry forward knowledge and skills that are applicable in both contexts meet training outcomes. Specifically, we will incrementally extend the existing platform through (A) a modular, customizable character animation platform for animating autonomous virtual avatars, (B) a conversational interface whereby teachers can verbally communicate with virtual students, and (C) logical formalisms for specifying narratives which facilitate free-form interactions between teachers and virtual students. We provide a brief overview of the proposed enhancements below and refer the readers to [27, 38, 80, 85] for further implementation details.

Platform Condition	**User (Teachers)**	**Virtual Characters (Students)**
A (Finalized Year 1)	Scripted teacher responses	Scripted character responses
B (Finalized Year 1)	Teacher has agency	Scripted character responses
C (Finalized Year 2)	Teacher has agency	Character has agency

Table 2: We will incrementally develop and evaluate 3 versions of the virtual reality platform to investigate the role of user interactivity and character agency on teacher training outcomes.

Condition A (Baseline Platform): Discrete Choice Selection for Users and Scripted Virtual Characters

The baseline platform will support static interactions between the user (the teacher) and the virtual characters (students), authored as static scripts. The teachers interaction will be categorized into a set of discrete choices at each stage of the interaction. The agent (virtual student) will respond by "playing back" the pre-specified reaction and response, which was pre-authored in the narrative. Figure 3 illustrates a sample authored interaction between a teacher and a single student. The teacher is limited to discrete choices at each stage of the interaction, with corresponding pre-authored character responses. The authoring complexity of these branching structures [41] scales exponentially with increase in number of virtual characters, and possible teacher choices, thereby fundamentally limiting teacher interactivity and character agency.

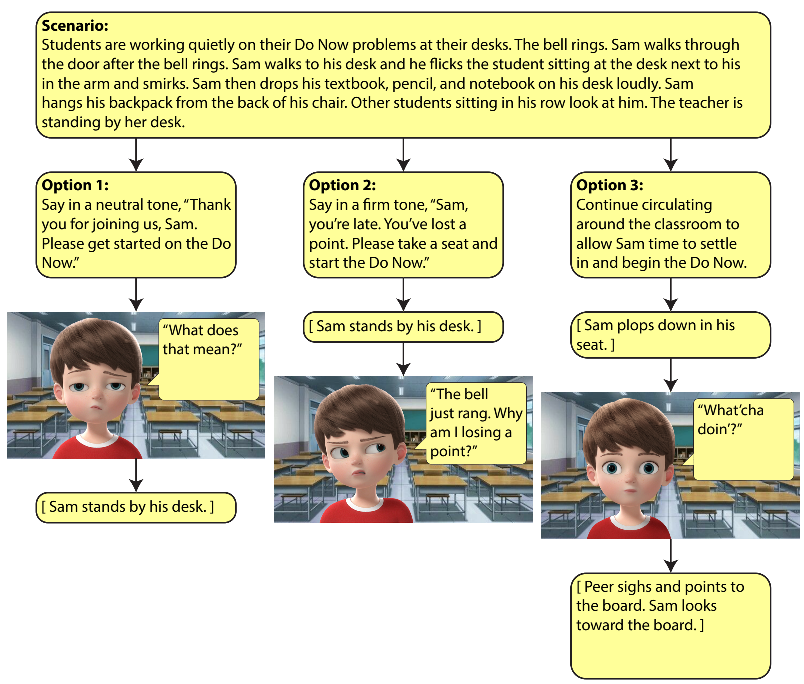

Fig. 3: Illustration of a narrative authored for the baseline condition of the platform. The teacher has a limited set of options at each stage of the interaction, with corresponding pre-authored character responses.

Animating Embodied Conversational Characters. We will leverage the existing infrastructure developed by Co-PI Shernoff [74, 76, 79]. This platform will be extended through a modular, customizable character animation platform, which supports the animation of virtual avatars including facial expressions and a variety of hand and body gestures.PI Kapadia has developed an open-source character animation platform, ADAPT [80] for designing and authoring functional, purposeful human characters in a rich virtual environment. ADAPT has been extensively used by multiple research institutions and industrial research labs, including UPenn, ETH Zurich, USC, and Disney Research due to its flexibile, modular, and extensible nature. It incorporates character animation, general movement, and rich behavior with modular, interchangeable components to produce narrative scenes. The animation system provides locomotion, reaching, gaze tracking, gesturing, sitting, and reactions to user input, and can easily be extended with more functionality due to a decoupled, modular structure. The behavior framework allows a user to fully leverage a character's animation, movement, and other modalities (e.g., speech) when authoring interactions between agents and users using an event-driven model. Figure 4 (left) illustrates an overview of the ADAPT framework and its central components.

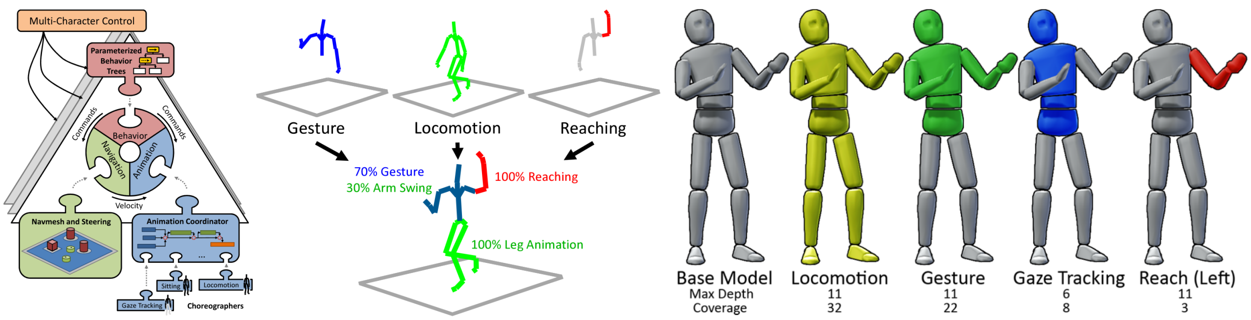

Fig. 4: (Left) Overview of ADAPT Framework. (Middle) Blending of multiple character states to produce a final synthesized character pose. (Right) Illustration on a humanoid character model.

ADAPT operates at multiple layers with interchangeable, lightweight components, and minimal communication between modules. The animation system performs control tasks such as locomotion, gaze tracking, and reaching as independent modules, called choreographers, that can share parts of the same character's body without explicitly communicating or negotiating with one another (see Figure 4). These modules are managed by a coordinator, which acts as a central point of contact for manipulating the virtual character's pose in real-time. The behavior level is split into two tiers. Individual behaviors are attached to each character and manipulate that character using the behavior interface, while a centralized control structure orchestrates the behavior of multiple interacting characters in real-time. The ultimate product of our system is a pose for each character at an appropriate position in the environment, produced by the animation coordinator and applied to a rendered virtual character in the scene each frame. For implementation-specific details on the underlying character animation system, please refer to [38, 80].

Condition B (User Interactivity): Free-form User Interaction and Scripted Virtual Characters
The discrete choice selection interface in the baseline platform will be replaced by a spoken conversational interface. The teacher will be able to freely interact with the virtual students by directly speaking to them in a microphone. The virtual characters will able to understand spoken utterances of the user, parse the language constructs, and identify the intent of the user. The perceived user intent will be mapped to a set of discrete possibilities which were pre-specified in the static narrative. As in the baseline condition, the virtual students will respond by "playing back" the pre-specified reaction and response, which was pre-authored in the narrative.

Speech Audio Processing and Natural Language Understanding. Figure 5 (left) shows the overall multi-modal emotion and user intent sensing structure in our proposed framework. This structure can detect and model emotions from various sources, parse speeches and analyze user intents. The RASA Natural Language Understanding platform [10] is used to extract user intents from the text recognized from speech. Depending on the scenarios, we can train different models accordingly. Every spoken sentence of the user can be categorized into one of the intents. Moreover, we also train the model with related entities, and during runtime, the system extracts them if they exist any in the sentence. Figure 5 (right) shows the procedure of the user intents classification. The voice sound signals are initially cut into pieces containing each spoken sentence. The speech signals are processed using platform-specific speech-to-text services to generate a stream of text. The returned texts are then enqueued into the message bus and waiting to be fed into the natural language understanding (NLU) services. For implementation-specific details, please refer to [14, 36, 85].

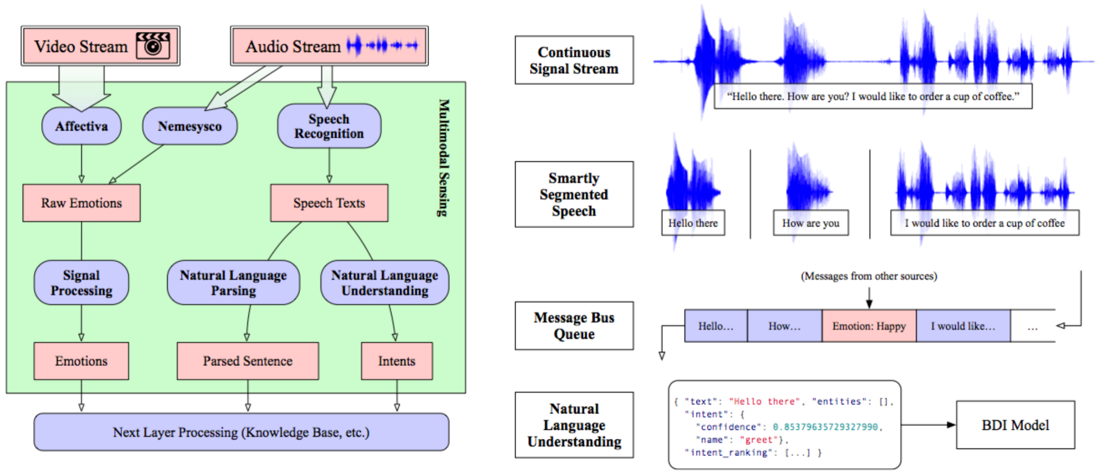

Fig. 5: (Left) Signal Processing and Natural Language Understanding for Conversational Agent. (Right) User Intent Classification for Natural Language Understanding.

Condition C (User Interactivity & Character Agency): Synthesized Virtual Characters and Free-form interaction for Users

The previous version of the platform (Condition B) only provides an illusion of user agency. Even though the user is permitted to freely interact with the platform and virtual characters through a spoken interface, the user interactions are mapped to a finite set of discrete choices which were authored beforehand by the narrative designer. This prevents the platform from robustly handling and accounting for previously unanticipated user input, where the teacher may adopt novel strategies to interact with the virtual students.

To alleviate this limitation, we will enhance the platform capabilities to support free-form user interactions and synthesized character responses. The user will have the ability to freely interact with the platform and the agents using the conversational interface (described above). This will allow the user to respond in any fashion they deem appropriate, depending on the current context of the interaction. Instead of using pre-authored responses, the virtual students will be able to synthesize new responses (facial expressions, gestures, and speech) to support unanticipated user input. This will afford users with the ability to engage in free-form interactions, and not be limited to the set of discrete choices, which were authored beforehand. Our system will support the ability to robustly handle unanticipated user input. This is made possible through the following technological advancements:

Natural Language Generation. Given the detected user intent, and the associated extracted entities from the user's spoken utterance, the agent formulates a plausible multi-modal response, which includes animations as well as a verbal response. We will use a retrieval-based natural language generation system to generate plausible natural language responses, in response to detected user intents. The main steps involved in generating a natural language response include: (1) Process natural language user input using the NLU services described above to parse text, identify user input, and extract relevant entities. (2) Select appropriate response template (frame) based on user input. (3) Populate response template to generate response candidates. (4) Apply advanced matching models to compute similarity (or relevance) score between candidates and the input message. (5) Rank the response candidates with a pre-trained matching model, and select top response. For more details on the underlying natural language generation system, please refer to [8, 100]. The text is then fed to a speech-to-text service [33] to generate a spoken response for the character.

Synchronized Facial Animations, Hand and Body Gestures. The synthesized spoken utterance will be used to generate plausible facial expressions, hand and body gestures, for the animated virtual students. Specifically, we will enhance the capabilities of the animation platform described above to include a rule-based system for facial expressions, and gestures for conversational agents [11, 59].

Interactive Behavior Trees for Multi-modal Character Response Generation. We will replace the static branching structures used in the first two platform conditions with Interactive Behavior Trees (IBT's) [38] to synthesize multi-modal character responses (spoken utterance using natural language generation method described above, along with synchronized facial animations, hand and body gestures). PI Kapadia and his colleagues have developed extensions to Behavior Tree formalisms, to facilitate the authoring of free-form, non-linear, multi-actor (humans or agents) interactions, where the specification can robustly handle unanticipated input, while still preserving overall narrative intent. These formalisms, termed as IBT's have been well studied (both practically and theoretically) and have the following features:

1. The logic to monitor user input is completely decoupled from the specification of the narrative. This facilitates the authoring of narratives, which are not limited to discrete user interactions at each stage in the narrative.
2. The authored narratives can be specified in a modular, hierarchical fashion (taking advantage of the inherent hierarchical structure of behavior trees), thus facilitating the scalable authoring complex narratives.
3. There is support to robustly handle unexpected input using implemented strategies for narrative mediation and/or interruption.

Figure 6 provides a simplified illustration of an IBT used to synthesize multi-modal responses in an embodied conversational agent, in response to spoken user input. It illustrates logical constructs for responsiveness to stimuli and the interplay between multi-modal stimuli. The right subtree of the root node uses the responsiveness structure for a single stimulus to listen for the end of a user's speech. This subtree is what maintains the agent's adherence to the phases of conversation. When the user begins to speak again, the subtree is interrupted and waits until the user stops speaking before attempting to deliver a response. The left subtree is responsible for the agent's verbal and nonverbal acknowledgements of the user's emotions. It has a higher priority than the right subtree so that when a verbal acknowledgement is elicited, the left subtree is able to interrupt the right subtree. Note that these logical formalisms are complementary to behavior markup languages [44] for multimodal behavior generation.

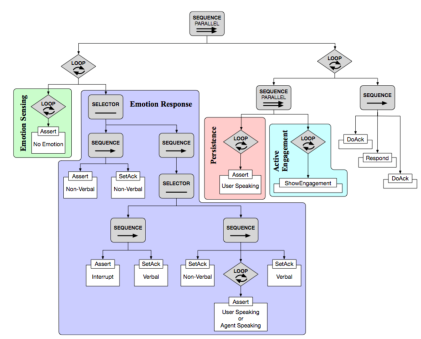

Fig. 6: Illustration of Interactive Behavior Tree for Designing Human-Agent Interaction.

Narrative Design: We will author the following narrative for each platform condition. The teacher will engage with four virtual students who are the protagonists. There are two inattentive and hyperactive characters (one second grader, one fifth grader) and two aggressive, argumentative, noncompliant characters (one second grader, one fifth grader). The narratives reflect the functional link between antecedents and consequences with a heavy emphasis on the influence of the environment and how teachers and peers respond that contributes to maintaining disruptive behavior [77]. The narrative progresses such that the protagonists escalate (become more off-task or more argumentative) or de-escalate (become more engaged and follow instructions) based on the response that the teacher selects. Figure 1 illustrates example interactions between the teacher and one student, using each of the 3 platform conditions.

Platform Deployment. The proposed virtual training platform will be deployed as a cloud-based web service (WebGL based) which teachers can login to, and use using existing computing systems (standard desktops or laptops). Standard control interfaces (keyboard and mouse, microphone for voice-based input) will be used. The platform will be built using the Unity 3D Game Engine (www.unity3d.com) to simulate a virtual classroom environment with four virtual characters (two second graders and two fifth graders), which the teacher can interact with.

We will systematically study the usability of prototype A, B, and C (years 1 and 2) and impact of teacher agency and character agency when using the virtual training platform, and interacting with the virtual student avatars, on proximal outcomes (i.e., teacher engagement and immersion) and distal outcomes (i.e., teaching effectiveness and student behavior). An overview of the studies is outlined in Table 1, and described in the thrusts below.

Thrust 2: Platform Usability Studies

During years 1 and 2, three cohorts of preservice teachers (n=12, N=36) will participate in formative usability evaluation sessions at Rutgers University. Figure 7 [94] illustrates estimated sample sizes needed for formative evaluations and diminishing returns associated with additional users, with 5 needed to identify 80%, and 9 needed to identify 95% of errors. Therefore, 12 teachers per cohort should identify the majority of usability problems in the three platforms. Advanced trainees will be recruited from a required course offered at the Graduate School of Education at Rutgers during their final semester (after field placement) targeting students in the Urban Teaching Fellows program. We will use a standardized concurrent think aloud (CTA) protocol used by Dr. Shernoff in her prior research. Participants will be instructed to verbalize their thoughts (think aloud) as they interact with each prototype [16, 37]. Audio capture software will record verbalizations and video recordings will capture computer screen and user on-screen interactions. A second video track will capture user gestures, grimaces, and overt behaviors indicating user problems [93]. Teacher trainees will complete research measures and receive compensation at the end of each formative evaluation session. The teachers will use the platform for 1.5 hours in the lab for each CTA session.

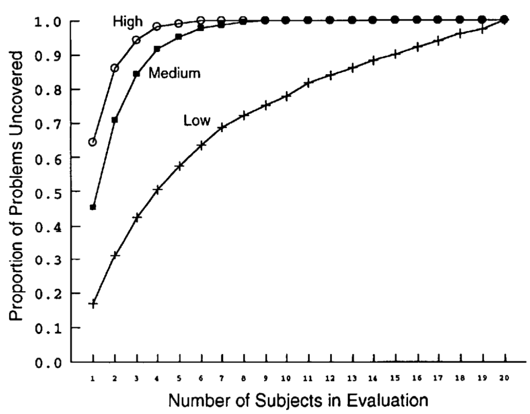

Fig. 7: The proportion of usability problems uncovered is shown as a function of the number of subjects for all problems at a given level of severity. More severe problems tend to be uncovered within the first few subjects [94].

Research Question. The main aim of these studies is to systematically evaluate the usability of each platform condition and to iteratively refine the platform (all conditions) to support the feasibility study, and the randomized controlled trial in Years 2 and 3.

Dependent Measures. A variety of measures will be collected using self-reporting, and logging of the activities of the teachers on the web platform to evaluate platform usability. Teachers participating in the lab-based formative assessments will be assessed with the following measures:

1. *System Usability Scale.* The System Usability Scale (SUS [6]) consists of 10 items measuring overall system usability and user interaction with technology-based interfaces. Teachers rate (1= *strongly disagree* to 5 = *strongly agree*) whether they would use the system frequently, ease of use, and whether the system is functionally consistent and well-integrated. SUS scores result in a global measure of system usability (α = .9) with all items summed and multiplied by 2.5 to obtain an overall system usability value from 0 (low usability) to 100 (high usability [6]).

2. *Questionnaire for User Satisfaction* [13] measures quality and satisfaction with human-computer in-

terfaces and has an overall α = .94.

3. *Concurrent Think Aloud Protocols (CTAs)* are a direct method for detecting the number and type of usability issues that emerge during a formative usability evaluation that would be difficult to obtain through observation alone [16, 37].

Analysis. We will review CTA transcripts, screen captures and video recordings to summarize the number of benchmark tasks completed, time required to complete each task, number of errors encountered, and percentage of users meeting each learning objective during the formative evaluation sessions. Numeric usability ratings will provide the team with an initial indication of user attitudes toward the system given learnability, system functionality, and ease of use. The research team will identify predominant usability issues and reach consensus on user benefits associated with each re-design recommendation (1 = Very Low Benefit to 4 = Very High Benefit). We will also rate the cost in time and resources associated with each recommendation (1 = Very Low Cost to 4 = Very High Cost). Fifth, we will calculate a cost/benefit ratio for each re-design recommendation, prioritizing low cost/high benefit revisions and coming to consensus on revisions with equal costs and benefits.

Thrust 3: Feasibility Studies to Assess Usage, Knowledge and Skill Transfer

During year 2, the feasibility of Prototype A and B will be examined with a sample of 40 teachers (n=20 will use Prototype A and n = 20 will use Prototype B).
Research Question. The goal of this study is to assess if the teachers use the platform as intended, and identify reported knowledge and skill transfer in teachers from using the virtual platform.
Dependent Measures. The following measures will be collected and analysed:

1. *Usage Measures.* To examine whether teachers use each system as designed, tracking logs will record the frequency and duration of each training session along with other teacher interactions with the system.

2. Teacher Knowledge of Evidence-Based Practices.. We will assess teacher knowledge of behavioral principles via an 11 item multiple choice measure [46]. A total percent of correct responses is calculated. Scores on the knowledge measure showed convergent validity with teachers' mental health literacy (r = .32) and are significantly related to teacher report of receptivity to various consultation strategies [58]. The Knowledge test will be completed by teachers at baseline and Time 2.

3. *Teaching Strategies Questionnaire* (TSQ [96]) assesses teachers' reported use of the evidence-based behavior management practices including 26 items measuring Frequency of Positive/Proactive Strategies (e.g., praise; α = .80) and Frequency of Inappropriate Strategies (e.g., redirection; α = .73) rated on a 5-point scale (1 = *Rarely/Never* to 5 = *Very Often*). Teachers will complete the TSQ at baseline and Time 2. In addition, teachers will complete the Confidence Managing Classroom Behavior subscale which includes two items measuring teachers' confidence managing current and future behavior problems (1 = *Not Confident* to 7 = *Very Confident*; α = .91) after each training session.

4. *Classroom Practices Questionnaire* (CPQ [66]) assesses teachers' perceived use of evidence-based instructional and behavior management practices (seven items) and students' academic (8 items) and behavioral functioning (7 items). All items are rated on a 7-point scale (*Very Much Worse to Very Much Improved*). Teachers will complete this measure at baseline and Time 2.

Analysis. Two level linear mixed-effects models will be specified using data collected on the sample of teachers at two time points. Our primary interest is in the slope parameter to examine the changes in teachers knowledge and skills in behavior management over time. Close monitoring of the tracking logs will assess utilization of the system as designed. Associations between dosage and knowledge and skill transfer will inform a threshold for dosage during the final year.

Thrust 4: Impact of Character Agency and User Interactivity on Teacher Training and Student Outcomes

During year 3, schools who meet our inclusion criteria (70% or more of students qualifying for free or reduced lunch) will be randomized to one of three conditions (Condition A = one school; n = 25 teachers, Condition B = one school; n = 25 teachers, and Condition C = one school; n = 25 teachers) for a total of N = 75 teachers. Condition C tests the incremental value of adding character and teacher agency to the training in terms of teacher engagement, skill development, and student behavior.

The primary focus of the study is supporting teachers to improve upon the routine instructional practices already being delivered in their classrooms. Although we are not intervening directly with students during the study, we are interested in whether improvements in teacher instruction impacts student learning and behavior. Therefore, approximately 250 students who are at-risk for behavior problems (e.g., difficulty paying attention and following directions) in teacher classrooms will be the focus. This includes: (1) teacher assessment of student behavior and engagement; (2) existing measures of student achievement.

Research Question. The primary aim of this study is to evaluate the role of character agency and teacher interactivity on teacher engagement, skill development, and student behavior

Dependent Measures. Teachers participating in the study will complete the TSQ and CPQ in addition to being assessed with the following observation measures described below. All measures described in the feasibility study (Thrust 3) will also be collected.

1. *The Classroom Strategies Assessment System* (CSAS [66]) assessed teachers' use of evidence-based instructional and behavior management strategies. The CSAS includes Strategy Counts, Strategy Rating Scales (Instructional and Behavior Management Scales), and a Classroom Checklist (for a detailed description please see [65, 67]). Strategy counts includes the raw frequency of behavior praise statements used during instruction (i.e., verbal or nonverbal statement or gesture to provide feedback for appropriate behavior). The second part includes indicators of high-quality behavior praise statements (e.g., specific verbal praise, gives immediate praise following appropriate behavior). Using the Strategy Rating Scales, these high-quality praise indicators were rated on a 7-point Likert scale of observed frequency and recommended frequency after a classroom observation. The recommended frequency versus observed frequency items yield a total discrepancy score (i.e., larger scores reflect a greater need for change in practice). Psychometric studies suggest adequate factor structure, internal consistency, inter-observer agreement, test-retest reliability and freedom from item bias [67]. CSAS scores also predict student achievement as measured by state testing [68].

2. *Student Outcomes.* Teachers will refer 3-5 students at risk for behavior problems and will be assessed with the following measures:

   (a) *Problem Behavior Subscale (30 items) of the Social Skills Improvement System* (SSIS [29]) will be completed by teachers for target students. This subscale measures behaviors interfering with behavioral competence on a 4-point scale (*Never* to *Always*). The SSIS has high internal consistency, test-retest and inter-rater reliability, and external validity with established measures of social and behavioral functioning (e.g., BASC [69]).

   (b) Student reading and math achievement. We will work with authorized school personnel to access de-identified student achievement data in reading and mathematics. Many districts administer the TerraNova [52] Reading and Mathematics scales three times per year that evidence internal consistency of .88, test-retest reliability of .76, and predictive validity coefficients of .75. Achievement data will be collected by designated school site coordinators and data will be de-identified by school district personnel by generating a pseudo ID using a random number.

Analysis. Three level mixed-effects regression models will compare outcomes between conditions, with time points (level 1) nested within students (level 2) and students nested within teachers (level 3). Variability at the teacher and student levels will be modeled using the random intercept and random slope. Our primary interest is in the slope parameter to examine the changes in teachers knowledge and skills in behavior management over time and changes in student learning and behavior over time. For teacher-level outcomes, prior gaming experience at baseline and teacher demographics will be included as covariates.

4 Intellectual Merits

The proposed research activities will concurrently advance our technology goals, together with our learning and educational goals.

Technology Goals. A key deliverable of this proposal is the development, deployment, and evaluation of a virtual training platform where teachers can fully immerse themselves in virtual classrooms and engage with fully realized, autonomous virtual students which can express themselves using facial expressions, hand and body gestures, and spoken language, using a conversational interface. These significant advancements will push the boundaries of agency and interactivity in virtual reality training platforms.

Learning and Education Goals. As the achievement gap widens, there is a pressing need for teachers working in disadvantaged schools where students are at greatest risk for academic failure to develop their behavior management skills in a safe, low-consequence-for-failure environment. Adding agency and interactivity to the virtual traing platforms is theorized to create a more dynamic, engaging, effective training system that supports transfer of learning from one setting (e.g., virtual classroom) to a new setting (e.g., live classroom). This type of training in behavior management provides an unprecedented opportunity to augment existing support to teachers and foster the dissemination and implementation of effective services that can enhance student achievement and well being [4].

5 Broader Impacts

Student achievement is severely compromised in urban low-income schools. African American youth score lower than white youth in math, science, and reading (National Center for Education Statistics, 2000).Teachers working in high poverty schools also face overwhelming challenges managing disruptive behaviors with studies highlighting that behavior problems as one of the most robust predictors of turnover [34]. Teacher skill and competence in behavior management is a critical mediator of student behavior problems with teacher skills in behavior management empirically linked to student achievement via its impact on effective instruction and opportunities for learning [4, 17, 18, 56].

The proposed work provides an opportunity to transform the landscape of teacher professional development, educator quality, and student well-being by providing realistic, accessible, engaging, sustainable support to help teachers enhance their practices with our most vulnerable learners. Effective prevention of disruptive behaviors within classrooms can also reduce referrals for more costly services for students exhibiting behavior problems and reduces referrals for special education and identifying students with emotional and behavioral disabilities. Academic achievement may be especially important as a protective factor for urban, African-American children, by attenuating the effects of negative life events such as school dropout, teenage pregnancy, and family conflicts [86].

Undergraduate and K-12 Educational Impact. Broadening Participation in Computing. The PI's will bring a broad range of research experiences to undergraduate students at RU, and K-12 students. Through established programs at Rutgers (e.g., ARESTY Undergraduate research program), they will continue to engage undergraduate students on research projects, and host 2 K-12 students in his lab each summer to introduce them to STEM/Cyberlearning research.

Multi-disciplinary Graduate Education and Postdoc mentoring The PI's and their mentees will have regular weekly meetings to update progress and share ideas. In Fall 2020, PI Kapadia will develop a course on "Intelligent Virtual Agents for Education", open to students in Computer Science, and the Graduate School of Applied and Professional Psychology (GSAPP). Students from these departments will form teams to facilitate cross-fertilization of ideas. The postdoc will give invited lectures in the course and co-supervise students (see postdoc mentoring plan for more details).

Dissemination to Research Community. Course materials and the proposed virtual training platform developed here will be disseminated through a project website (hosted at RU and github) designed specifically to present the research outcomes and progress. It will include major publications in scientific venues, exemplary results with visualization to help understand the subject matter, and sample course materials to enable broad dissemination.

Open-Source Software. A key deliverable of the proposed research activities will be the virtual training platform and its associated tools (e.g., software solutions for authoring narratives, embodied conversational avatars). We will host the platform and its source code online to enabled wider adoption, and spark future research in this area. We envision the applicability of the technology in a host of other training applications, beyond those studied in this proposal. PI Kapadia has an established record of releasing software packages [39, 81].

Evaluation of Impact. Several quantitative and qualitative measures will be used. For dissemination outcomes, we will utilize the project website visitor and download counts and citations as KPIs. The PI will closely monitor targets for educational, underrepresented, and minority group outreach.

6 Project Timeline

Figure 8 outlines the anticipated timeline of the proposed research activities, assuming an October 2020 start date. The team is expected to get IRB approval for the outlined user studies, prior to the start date. The timeline for platform development is as follows: (1) The baseline version of the platform (Prototype A) is expected to be developed by March 2021. (2) Prototype B is expected to be developed by August 2021. (3) The complete platform (Prototype C) is expected to be implemented by June 2022. Concurrent with platform development, we will conduct studies to advance our learning and education goals. We will conduct the usability study of Prototype A during April – July 2021, and iteratively refine the platform based on findings. Similarly, the usability of Prototype B will be performed during September – December 2021. In parallel, we will begin teacher recruitment for the feasibility study (Thrust 3). The feasibility study of Prototype A and B will be performed between December 2021 – April 2022. The usability of the final platform (Prototype C) will be conducted during June – Septmber 2022, and final refinements will be made. Subject recruitment for the final randomized controlled trial will occur during September – November 2022. The final phase of the research (November 2022 – September 2023) will involve conducting the randomized controlled trial, analysis and dissemination of findings.

YEAR 1	Year 1: October 1, 2020 - September 2021											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
IRB approval, hire and train staff, observer training	•	•	•									
Prototype A (Scripted Agents) finished					•	•						
Assess usability of Prototype A and make iterative refinements							•	•	•	•		
Prototype B (Character Agency) finished											•	
Assess usability of Prototype B and make iterative refinements												•
Recruit teachers to participate in feasibility study (year 2)												•
YEAR 2	**Year 2: October 1, 2021 - September 2022**											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Assess usability of Prototype B and make iterative refinements	•	•	•									
Recruit teachers to participate in feasibility study	•											
Baseline data collection for feasibility study	•	•										
Teacher training with Prototype A and B			•	•	•	•	•					
Recruit schools to participate in pilot study (year 3)							•	•				
Post-testing data collection, downloading, cleaning, and analyses								•	•	•		
Prototype C (Teacher Agency) finished									•			
Assess usability of Prototype C and make iterative refinements									•	•	•	•
Recruit and consent teachers to participate in pilot study (year 3). Baseline data collection.												•
Analysis and dissemination of findings										•	•	•
YEAR 3	**Year 3: October 1, 2022 - September 2023**											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Recruit and consent teachers to participate in pilot study (year 3). Schools randomized to condition A or B or C. Baseline data collection completed.	•	•										
Teacher Training		•	•	•	•	•	•					
Post-testing data collection, downloading, cleaning, and analyses								•	•			
Analysis and dissemination of findings. Follow up grant applications										•	•	•

Fig. 8: Timeline of Proposed Research Activities.

7 Results from Prior NSF Support

PI Kapadia's work is currently being funded by two NSF grants (#1703883 "CHS: Medium: Data-Driven Biomechanically Accurate Modeling" 7/1/17 – 8/31/20, #1723869 "IS S&AS: FND: Reflective Learning of Stochastic Physical Models for Robust Manipulation" 9/1/17 – 8/31/20). **Intellectual Merit:** These projects both focus on realistic modeling and simulation of human behavior, and have produced the following publications [9, 14, 15, 20, 25, 27, 36, 49, 63, 70, 71, 83–85, 92, 98]. **Broader Impacts:** These projects will contribute to areas of human modeling and understanding, and the design of robotic systems.

Co-PI Shernoff's work is currently funded by a US DOE Grant (Institute for Education Sciences) (#R305A150166: "Interactive Virtual Training for Early Career Teachers in High Poverty Schools" 7/1/15 – 6/30/20." **Intellectual Merit**: This project focuses on the development and pilot testing an interactive virtual training platform in which teachers working in high poverty schools can hone their behavior management skills with disruptive avatars in a virtual training environment and have produced the following publications [74–76, 78]. **Broader Impacts**: This project serves as the foundation for the proposed work designed to shift the landscape of teacher professional development and student learning in high poverty schools.

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Cyberlearning: The Role of Agency and Interactivity for Virtual Training of Teachers in High Poverty Schools
Supplementary Document: Data Management Plan
PI: Mubbasir Kapadia, Rutgers University

Data Description

Data. As part of the proposal, we will generate and use the following types of data: (1) synthetic simulated data generated using our agent-based simulations, (2) human behavior data collected from desktop-VR and immersive VR experiments, and (3) survey results from user studies conducted on Amazon Mechanical Turk, or after the VR study sessions. All data obtained from human subjects (data collected using VR experiments and on AMT) will be in accordance to the Institutional Review Board (IRB) approval, which will be obtained prior to the start of the project.

Software. The main software deliverable of the proposed research activities will be a unified software framework for simulating human wayfinding in complex environments, using a cognitive agent model. The software framework, cognitive model, and its parameters (obtained from VR studies) will be hosted on github, and links will be made available on a project website.

Course Materials. Curriculum materials will include course materials and content we will design and implement during the project period.

The Standards for Data and Metadata Format

We will use an XML based format (as provided in the open-source crowd simulation framework developed by PI Kapadia [81]) to represent and store spatio-temporal data associated with the movement of agents (or human-controlled avatars) in virtual environments. In addition, we will develop and enhanced BIM specification which will be used to store environment specifications, and its associated features related to different information sources which influence wayfinding. This will be compatible with existing BIM standards.

Access and Sharing Policy

The PI will be responsible for managing, retention, and sharing all data collected. All data will be accessible by the PI, postdoc, and students who are participating in the research project. External research collaborators will obtain access to the data upon PIs' approval. A written form of usage agreement will be prepared and a signed form will be required for any external researchers following the IRB protocol. Data will be stored in secured network attached storage. Access credentials will be exclusively controlled and managed by the PI.

Reuse, Redistribution, and Derivative Production Policy

The datasets, software, and curricular materials, will be available to the academic and research community following an open source policy as explained in the Project Description. All data obtained from user studies will be annonymized prior to release, and will be be available upon receipt of the signed usage agreement form following the IRB protocol and approval from PI.

Archiving and Preserving Data and Research Products

All data, software, course materials, and research publications will be managed on a project website, generated as part of this project. Visitors will be able to find the data they want or related contact information easily. The data storage and the project website will be maintained as long as the PI maintains their current affiliations. In the case of relocation, they will continue to maintain data from this project according to the policies/procedures of any new institutions.

Dissemination Plan

A project website will be established to disseminate the results and the code developed during the project. All Graduate Students and the Post Doctoral researcher will present research findings in their respective academic venues. The PI will also encourage undergraduate students to present their project outcomes in undergraduate research as well as main academic venues. The travel cost budgeted in the proposal is related to these dissemination activities.The results and data from this study will be made accessible to other researchers, teachers, and the general public to support secondary data analyses and dissemination of study findings.

Cyberlearning: The Role of Agency and Interactivity for Virtual Training of Teachers in High Poverty Schools
Supplementary Document: Collaboration Plan
PI: Mubbasir Kapadia, Rutgers University

In this document, we explain the work distribution throughout the project. The collaboration efforts and the management structure are organized around the objectives of the project, the outcome assessment, and the research team expertise. The collaborative effort will extend beyond the scientific research to teaming on platform development, student supervision and training, and educational activity.

The team has been carefully selected for their synergistic and collaborative abilities, their leadership, and expertise to conduct this demanding, transformative and collaborative type of proposed research. In the following we provide details on the type of research and contribution that each participant will contribute.

Research Team Members and their Expertise

The team members and their complementary research expertise are as follows:

- Mubbasir Kapadia, Assistant Professor, Computer Science, Rutgers University (Artificial Intelligence, Virtual Reality, Intelligent Virtual Agents)
- Elisa Shernoff, Associate Professor, Graduate school of Applied and Professional Psychology, Rutgers University (Virtual Reality for Teacher Training in High Poverty Schools)
- Postdoctoral researcher, Computer Science, Rutgers University (to be hired in Year 1; expertise in Virtual Reality Training and Intelligent Virtual Agents)
- Postdoctoral researcher, Graduate school of Applied and Professional Psychology, Rutgers University (To be hired in Year 3; expertise in conducting and analysing human subject experiments)
- Carlos Muniz, 3rd year PhD student, Computer Science, Rutgers University (Virtual Reality Training, Embodied Conversational Agents)

PI Research Collaboration and Student Supervision

If the team is awarded the funding, a kick-off meeting will be held within a week of the announcement for all investigators, participating senior research personnel, and undergraduate/graduates students. A broad overview of the research activities will be presented and yearly research targets and deliverables will be set. We will hold biweekly meetings with the attendance of the PIs, postdoc, and students. Towards this end we plan to use social media tools such as Google Hangouts and Zoom, as well as in-person meetings as all project members are located on the same Rutgers campus.

For most of the research tasks, both PIs will contribute equally, depending on their respective expertise. PI Kapadia will spearhead the advancements of the virtual reality training platform to support character and teacher agency. Co-PI Shernoff will design and run the user studies to investigate the role of agency and interactivity in virtual reality teacher training. She will also spearhead subject recruitment and analyses, together with her postdoc. Muniz and the CS postdoc will work closely with Kapadia on platform development, and assist Shernoff in conducting the usability, feasibility, and final studies.

The PI's have been working together since January 2019 to conduct preliminary studies in support of the planned research activities, described in this proposal. PI Kapadia has been supervising Muniz (PhD student) since Fall 2017.

Collaboration with External Parties.

One high poverty school district will partner with the investigative team (see letter of collaboration) to complete the usability studies (year 1), feasibility study (year 2) and final study (year 3). Eighty seven percent of students are eligible for free or reduced lunch in 2017-2018. This school district has 22 schools characterized as 93% African American, 6% Latinx, and 1% European American to meet inclusion targets for the planned study. Co-PI Shernoff has strong collaborations with this district via an ongoing funded grant and the district has expressed enthusiasm for the proposal. Co-PI Shernoff will allocate several months during Years 1 and 2 (see Timeline) to recruit schools and teachers. Our recruitment strategy derives from PI

Shernoff's previously funded studies and begins with contacting principals by email to introduce the study and invite discussion. Next, we will schedule meetings with principals and other staff designates to provide details and secure consent. We expect strong participation from the district given Co-PI Shernoff has been very successful involving teachers in her prior research, obtaining consent rates of over 90% in several successive studies in high poverty schools (Shernoff *et al.*, 2016; 2017; 2018).

Project Management and Conflict Resolution

Kapadia as overall PI will be responsible for all aspects of the projects. Both PI's will be involved in all aspects of the project with PI Kapadia spearhead platform development, and Co-PI Shernoff spearheading teacher recruitment and human-subject experiments. As both PIs have been successfully collaborating and are co-located on the same campus, there is no issue with management and conflicts. However, in case there is a conflict the PI will resolve it based on properly scheduled meetings and discussions.

Cyberlearning: The Role of Agency and Interactivity for Virtual Training of Teachers in High Poverty Schools
Supplementary Document: Protection of Human Subjects
PI: Mubbasir Kapadia, Rutgers University

1 Risk to the Subjects

Human subjects involvement and characteristics

Participants will be recruited for the experiments from the pool of undergraduate and graduate students in Rutgers University. Subjects will participate in two types of studies: (1) Desktop-based VR studies, where subjects will use a keyboard and mouse to navigate a virtual character in a 3D virtual environment, under a variety of different environment and crowd conditions. (2) An Immersive VR experiment where subjects will wear a head mounted display (HMD) to explore a virtual environment under different conditions. In addition, we will also conduct data collection studies on Amazon Mechanical Turk, where subjects will be shown images and/or videos of characters and/or environments and be asked to answer discrete choice-based questions.

Sources of materials

All data that could be used to identify a subject will be filed by an anonymous subject code and stored in locked cabinets in PI Kapadia's office at Rutgers University.

Potential Risks

Risks are minimal. The study procedure will be explained to participants and they will be asked to sign a consent form. The activities that subjects will perform during the experimental testing are regular classroom activities. These tasks will not expose the subject to injury risk beyond that existing in a regular classroom setting. For the immersive VR study (HMD-based), subjects will be clearly notified of the potential side-effects associated with using head-mounted displays.

2 Adequacy of Protection Against Risks

Recruitment and Informed Consent

VR studies. Subjects will be recruited from the undergraduate and graduate student body at Rutgers University. Subjects will use a keyboard and mouse to navigate a virtual character in a 3D virtual environment, or use a Head Mounted Display, under a variety of different environment and crowd conditions. The study will be introduced to the potential subject by PI Kapadia, his postdoc, and/or his graduate student. The recruiting person will explain the details and the subject's involvement,

Amazon Mechanical Turk. Subjects will be recruited from the pool of workers available on Amazon Mechanical Turk. Subjects will be introduced to the study through a project-specific consent document, which will be approved by the Rutgers IRB and clearly describe to the subject all the procedures and protocols in the study, and what data will be collected. Subjects will be asked to consent that they have read and understood the consent document before proceeding with the study.

Protection against Risk

The activities that the subject will perform during the experiments are low-risk activities for subjects, involving using a web-based platform on a standard desktop computer with a keyboard/mouse interface. These tasks will not expose the subject to injury risk beyond that already experienced as part of their daily life.

For the study involving the use of an HMD, subjects will be clearly notified of the potential side effects of using HMD's (e.g., nausea). We will use the latest generation of devices to minimize any latency or visual artifacts that may contribute to these symptoms. All necessary measures will be taken in the design of the virtual environments and method of interaction, to minimize visual stimuli which may cause discomfort. Before the study begins, a short tutorial session will be held to make the subject comfortable with using the hardware. If the subject exhibits any symptoms, the experiment will be stopped and the subject will be provided with the necessary assistance.

3 Potential Benefits of Proposed Research to Subjects and Others

Subjects will be compensated at the rate of 20 USD per session, with each session lasting less than 1 hour. The knowledge derived from this study will contribute to our understanding of how various information sources contribute to the decisions humans makes when navigating in complex environments.

4 Importance of the Knowledge to be Gained

The knowledge gained from these experiments will be used to refine the various components of the cognitive agent model of human wayfinding in complex environments.

5 Data and Safety Monitoring Plan

This study is not considered a clinical trial. The findings from each subject will not be used for their medical decision-making and the data collections pose no more than minimal risk for subjects.

Adverse event monitoring: Any adverse events that occur during experiments will be immediately analyzed to determine if a change is necessary to the anticipated benefit-to-risk ratio of study participation and to determine whether the study should continue as designed, be changed, or be terminated. If an injury occurs, the research staff will provide immediate first aid and the subject will be referred for further evaluation and treatment to his or her attending surgeon. The occurrence of adverse events will be monitored on an ongoing basis for the duration of the study and will be discussed by the investigators. If a serious or unexpected adverse event occurs, it will be reported immediately to the appropriate Institutional Review Board in accordance with IRB regulations. If an unexpected adverse event occurs, the investigators will re-assess the risk/benefit ratio of the study and submit any modifications deemed necessary to the IRB for approval.

Protection of privacy and confidentiality: The study procedures designed to protect the privacy of subjects and confidentiality of the research data will be monitored throughout the study by the PI. Subjects will be identified by a numbering system known only to the study researchers. When data are recorded, only the subject ID number will be used for identification. Information that links the ID number given to each subject and that subject's name or other personal information will be stored in a locked cabinet at Rutgers University, and will be accessible only to the researchers involved in the study. No individual subject information will be revealed after study participation or with the publication of results. Individual subject results will be made available to the doctor treating the subject and the doctor may share with a participant his/her individual test results.

The PI will conduct a regular review of accrued research data and other relevant information so as to ensure the validity and integrity of the data and to assure there is no change to the anticipated benefit to-risk ratio of study participation. All investigators will monitor current literature for related studies that may have an impact on the safety of study participants or the ethics of this research study. The principle investigator will conduct an ongoing review of study procedures so as to ensure that the privacy of research subjects and the confidentiality of their research data have not been violated. Data will be monitored following collection and processing. This process is typically completed one to two weeks after the data collection session. Subject safety will be continually monitored during data collection procedures.

6 Inclusion of Children, Women, and Minorities

For the purpose of this classification, a child is defined as an individual under the age of 21. No children will be involved in this study. We will target recruitment of an equal number of males and females. We do not have reason to believe that the racially or ethnically related factors will impact on the findings of our studies; however, we will target subjects in proportion to our estimation of the demographic makeup of the northern New Jersey area. We will not exclude any individual from enrollment in the study based on racial or ethnic group.

Cyberlearning: The Role of Agency and Interactivity for Virtual Training of Teachers in High Poverty Schools
Supplementary Document: PostDoc Mentoring Plan
PI: Mubbasir Kapadia, Rutgers University

The postdoctoral researchers will play an integral part in this project. During the first year, a postdoc will be hired in the Computer Science Department at Rutgers University (under the supervision of PI Kapadia) to participate in platform development and usability studies. During Year 3, a postdoc will be hired in the Graduate School of Applied and Professional Psychology at Rutgers University (under the supervision of Co-PI Shernoff) to oversee the user studies to evaluate and compare the different platform conditions, and assess the role of agency and interactivity in virtual reality teacher training.

We will establish a mentoring program. The program will include participation in an 'Ethical Practices in Research' seminar that will be offered biannually at Rutgers. Covered topics include management of traditional and digital intellectual property in a global environment and plagiarism.

The Rutgers PIs will mentor the postdocs thoroughly in the areas of research, teaching, academic engagement, establishing closer research ties to other related research groups, and to launch an independent line of research and secure a faculty position in their chosen discipline. As with previous post-doctoral associates, we will pay attention for the postdoctoral colleagues to build a successful portfolio for an academic career. Specifically, we will make every effort to cover the following items for both postdoctoral candidates:

1. The PI's will serve as the postdocs mentors respectively (described above), and oversee his/her research projects and provide overall career guidance. The postdoc will have the opportunity to interact with other faculty at Rutgers.

2. The postdoctoral researcher will participate in the weekly project meetings at Rutgers. She/he will also participate in the individual PI group meetings as well as a bi-weekly reading group, where the PI's students will review and discuss state-of-the art research papers in areas related to cognitive modeling, human behavior simulation, and wayfinding.

3. PI will encourage her/him to supervise some of the work of the graduate assistants and undergraduate summer interns at Rutgers in an effort to cultivate leadership qualities and to develop skills for effective team management. This engagement will provide valuable experience for a successful academic career. Both PI's regularly host undergraduate students to participate in research projects through the ARESTY research program, and the postdoc will be encouraged to participate in these initiatives.

4. The postdoctoral researcher will be encouraged to participate in all aspects of the grant cycle: proposal writing, annual report preparation, writing scientific reports, and preparing manuscripts for peer-reviewed journals, as well as conference proceedings articles and abstracts.

5. To develop and improve her/his teaching skills, the associate will offer lectures in pertinent undergraduate and graduate courses. In particular, the PI will encourage her/him to get involved in the proposed curriculum development.

6. The postdoctoral researcher will be encouraged to present lectures on his/her progress both within and outside Rutgers. PI Kapadia will introduce her/him to colleagues in conferences and symposia. She/he will be encouraged to act independently and accept invitations to visit universities and corporate research centers for lectures. PI will pay her/his expenses to present results and attend the key conferences in her/his field.

Success of this Mentoring Plan will be assessed by monitoring the postdoctoral researcher's progress toward her/his career goals after finishing the postdoctoral program.

Cyberlearning: The Role of Agency and Interactivity for Virtual Training of Teachers in High Poverty Schools
Facilities

PI: Mubbasir Kapadia, Rutgers University

Resources provided by the Department of Computer Science

The Rutgers University Department of Computer Science is located in the Hill Center, the CoRE Building and the CBIM structure on the Rutgers Busch Campus in Piscataway, NJ. This space amounts to more than 40K square feet comprising more than 100 offices, 18 research labs, 7 classrooms/labs, 30 service/printer/tech rooms, and 3 conference rooms. The CoRE building also has a 110-seat auditorium that is shared by the building's occupants. Faculty and project researchers have access to all of these facilities.

Administrative Support: The Department of Computer Science staff consists of 8 members, who will provide administrative support to the project. The staff includes two business specialists, one personnel specialist, one senior business manager, two administrative assistants and two clerical positions. This support staff handles the accounting and purchasing details, all personnel related matters, and proposal submission as well as publicity, academic issues, and support to the department chair.

Computing Resources - Laboratory for Computer Science Research (LCSR): LCSR is a technical center within Rutgers University. LCSR's mission is to provide technical and related administrative support for the research and related educational activities of the department. LCSR's personnel, computing, storage, networking and service facilities are described below.

LCSR Personnel: LCSR has a total full-time staff of 8 members. The support staff include two hardware operations, including computer and network installation and maintenance, two part-time student network and hardware technicians, three Unix support staff plus student programmers, one Database Administra- tor, two Macintosh and PC support personnel, eight part-time student operations staff, two Web and Database developers and one Associate Director. LCSR's personnel provide a stable and ongoing supply of technical research expertise in order to realize the experimental, system, and educational needs the professors, students and staff in the Department of Computer Science. LCSR staff members also initiate new projects to support advances in computer science research and education.

LCSR Physical Facilities: LCSR maintains 3 climate-controlled machine rooms, totaling approximately 1500 sq ft of class A data center space. These machine rooms house most of the departments compute servers, networking switches, storage servers, as well as project-specific servers from various Principle Investigator's (PI) laboratories. LCSR supports an educational laboratory, the ilab, with 75 seats. Each seat has a full desktop connected with a Gigabit Ethernet. In addition to supporting student projects, the ilab can also be used for instruction, with a podium, video projector and whiteboards available for lectures and other modes of instruction. In addition, LCSR support 2 more traditional classrooms, each with access to a video projector and whiteboards. LCSR also manages 3 conference rooms, one with video conferencing capabilities. The iLab facility will be used to conduct the desktop-based VR experiments, as outlined in the Project Description.

LCSR Computing and Data Storage Support: LCSR manages several computing clusters: undergraduate, ilab, graduate, and general-purpose research. The undergraduate cluster consists of 5 servers, serving approximately 1300 user accounts, with over 50 GB of centrally managed, backed-up storage. The ilab cluster supports the undergraduate laboratory, and contains 75 desktops, 2 large servers, 90GB of centrally managed storage, and serves over 1100 user accounts. The graduate cluster consists of 63 desktops, 2 large servers, and 80 GB of managed storage supporting 500 user accounts. The research cluster contains 49 quad-core or larger servers, with 600 accounts and 2 TB of managed storage.

For large computational needs, LCSR maintains a large 32-core server with 128GB of main memory and over 1.6TB of storage and a 16-core server with 64GB of memory and 1TB of storage.

Recently, LCSR also created a 'cluster' of 20 mobile phones. The phones run a full Linux operating system and Java programming environment, thus allowing faculty and students to investigate emerging mobile and ubiquitous computing applications. The phone cluster has been used by several PIs and in classroom settings.

The supported software packages across all these clusters includes various languages; including Java, PERL, Prolog, Lisp, Scheme, Eiffel, C, C++, and Fortran, as well as specialized tools for specific research areas, e.g. Mathematica, Matlab, Maple (Mathematical analysis packages), CPLEX (nonlinear optimization), R (statistics), Eclipse (software development), as well as document preparation tools such as TeX, LATex, OpenOffice, MS-Office, and Acrobat.

LCSR Networking Support: A large data network interconnects all of LCSR's facilities. The wireline network contains 43 switches and over 700 live ports. All desktops are connected at 100 Mb/s, except the ilab cluster desks, which are connected at 1 Gb/s. Most servers inside the machine room facilities are connected at 1GB/s. A small IPV6 network is also available.

LCSR supports a wireless network covering all areas of the department with 802.11b, 802.11g and 802.11a protocols. A total of 49 wireless access points provide coverage for over 113,000 sq ft.

Outside connectivity is provided via access to the Internet-II experimental high-speed national network. LCSR also maintains an extensive security infrastructure over the network, including firewalls, custom intrusion detection software, and provides port-mortem analysis of compromised machines.

LCSR Software and Development Services: LCSR provides numerous software and Web services to the department. These include Email, Web and database servers, an academic peer-review system, various file sharing protocols such as NFS, CIFS, and AFP. LCSR provides advanced communication services, including Voice Over IP (VOIP) and video conferencing.

LCSR is also a unique environment because it provides software development services for the department. LCSR maintains numerous in-house-developed applications, including services for graduate applicant and student tracking, student handin, course scheduling, and colloquium and talk scheduling services. LCSR has also developed lecture recording software (Lecture 123), Enterprise Wireless management systems (LAWN), and has assisted PIs with their unique software-development needs.

Resources Provided by the Graduate School of Applied and Professional Psychology

Co-PI Shernoff is a faculty member in the Graduate School of Applied and Professional Psychology at Rutgers. The graduate school has two nationally ranked APA Accredited Doctoral Programs that include numerous distinguished faculty members in clinical and school psychology with extensive experience with school-based intervention research. The Graduate School of Applied and Professional Psychology and its Center for Applied Psychology (CAP) have over 55 million USD in grant funding and over 17,000 square feet of office and research space. Existing offices house personnel involved in conducting school-based research, including faculty, full-time staff, and doctoral and undergraduate research assistants. These offices included conferencing space for internal project meetings and shared meetings with collaborators. They also include video screens and Polycom systems to conduct videoconferencing with partners. Personnel resources within the Graduate School of Applied and Professional Psychology are available to support pre- and post-grant award management and technological needs. All research suites are networked to secure, firewall-protected servers designed to protect access to sensitive data. Methodologists/statisticians with experience in research design methodology (e.g., experimental, quasi-experimental, correlational methods) and statistical approaches (e.g., multi- level modeling, latent variable modeling, and multivariate analyses) are available to provide research support and have been involved in numerous RCT investigations of school-based interventions requiring considerations about nesting of students and teachers within classrooms, within schools. Designated as a Research 1 University by the Carnegie Foundation and recognized as one of the top 62 research Universities in North America by the Association of American Universities, Rutgers University has extensive experience managing grants and state- of-the art resources (e.g., library, technological, space) for faculty research.

The Graduate School of Applied and Professional Psychology also includes significant resources to forge effective dissemination of project findings. Examples of these resources include state-of-the-art web-development capabilities and full-time professional staff dedicated to enhancing communications of project findings with community partners, policy makers, international and state leaders, and private foundations and donors.

Resources provided by the Computational Biomedicine, Modeling and Imaging Center

The PI is a member of the Computational Biomedicine, Modeling and Imaging (CBIM) research center, which provides them access to additional resources that can be used by the proposed project, where appropriate. The CBIM center has 11 faculty members and approximately 50 graduate students. It has access to almost 11,000 square feet of space, which includes a studio for motion capture, robotic equipment (see details below).

Human Behavior Capture and Analysis: The Center houses equipment for analysis of human behavior, including:

- 3DMF 4D face capture system. The system is capable of capturing detailed 3D facial models of subjects at 60fps. Collected data is being used to study facial nonverbal behavior and biomedical modeling of faces/head. The system includes a multicamera rig and the accompanying software suite for 3D capture and reconstruction.
- Vicon full body motion capture system (6 cameras). The system is capable of capturing full body pose at 60fps.
- Xsens MVN 3D real-time motion tracking system for indoor-outdoor full body motion capture. The system is used for movement and gait analysis research.

Computing Facilities: The lab is well equipped with iMac devices, laptop computers, printers, communication infrastructure and most major software packages relevant to Computer Science and Engineering. CBIM equipment includes 40 PC workstations, and 200TB database clusters. It also houses a dedicated computing cluster (4 Dell machines with 128 computing nodes). PI Kapadia has acccess to multiple Head Mounted Displays, obtained from his startup package, which will be used to conduct the VR studies.

Collaborators.

One high poverty school district will partner with the investigative team (see letter of collaboration) to complete the usability studies (year 1), feasibility study (year 2) and final study (year 3). Eighty seven percent of students are eligible for free or reduced lunch in 2017-2018. This school district has 22 schools characterized as 93% African American, 6% Latinx, and 1% European American to meet inclusion targets for the planned study. Co-PI Shernoff has strong collaborations with this district via an ongoing funded grant and the district has expressed enthusiasm for the proposal. Co-PI Shernoff will allocate several months during Years 1 and 2 (see Timeline) to recruit schools and teachers. Our recruitment strategy derives from PI Shernoff's previously funded studies and begins with contacting principals by email to introduce the study and invite discussion. Next, we will schedule meetings with principals and other staff designates to provide details and secure consent. We expect strong participation from the district given Co-PI Shernoff has been very successful involving teachers in her prior research, obtaining consent rates of over 90% in several successive studies in high poverty schools (Shernoff *et al.*, 2016; 2017; 2018).

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List of Project Personnel and Partner Institutions
PI: Mubbasir Kapadia, Rutgers University

1. Mubbasir Kapadia; Rutgers University; PI
2. Elisa Shernoff; Rutgers University; Co-PI

Cyberlearning: The Role of Agency and Interactivity for Virtual Training of Teachers in High Poverty Schools

Supplementary Document: Diagrams and/or screen shots

PI: Mubbasir Kapadia, Rutgers University

Please refer to Figure 2 in the **Project Description** for illustrations of the anticipated teacher experience when using all 3 versions of the proposed virtual training platform.