Interdisciplinary Collaboration and Establishment of Requirements for a 3D Interactive Virtual Training for Teachers

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ABSTRACT

Simulation-based training systems have proven effective in a variety of domains, both for facilitating the learning of skills as well for applying this knowledge to real life. Although difficulties managing students' disruptive behavior in classrooms has been identified as one of the main causes of teachers' turnover, only a handful of virtual training environments have focused on providing training to teachers, and still no clear methodologies exist for their design, their implementation, nor their evaluation.

In this article we discuss the methodologies employed by an interdisciplinary team of computer science and education researchers involved the development of the first of four iterative, increasingly sophisticated, prototypes of a web-based 3D Interactive Virtual Training Environment for Teachers (IVT-T). IVT-T simulates students with disruptive behaviors that teachers can interact with in a 3D virtual classroom, which provides teachers practice in managing classrooms, as well as feedback and reflection opportunities about their classroom behavior management skills.

We currently describe the processes we conducted to derive the main system requirements for IVT-T 1.0 (the system is still evolving), which led to our suggestions for general requirements, in addition to the next lifecycle steps we identified for the successful implementation of the final system.

KEYWORDS

Classroom Simulators, Virtual Learning Environments

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1 INTRODUCTION

Over the past two decades, simulation-based virtual learning environments (VLEs, which include simulations of the real world in a virtual environment) designed to provide practice to learn new skills have shown significant success in a variety of application domains (training of fire-fighters, procedural training etc. [7, 9]).

An educator's ability to prevent and manage behavior problems in a classroom is crucial for enhancing student achievement (particularly for struggling learners) [8]. Indeed, teachers, and early career teachers (ECT) in particular, identify disruptive behaviors as a stressful experience. Yet they receive limited training to develop behavior management skills [12]. ECTs are often left to practice these skills in real classrooms without support, and through a trial-and-error approach. Accordingly, disruptive behaviors are identified as one of the strongest causes of teachers' turnover [12]. Helping ECTs, and teachers in general, to refine these skills could have a significant impact on classroom interactions, on the facilitation of student learning, and on teachers' retention rates. Therefore, the creation of VLEs aimed at teaching coping skills could prove to be a tremendous asset. However, despite the clear need, there are to date only a handful of VLEs designed for this purpose [2, 3, 5, 6, 13].

In this article, we discuss the collaboration between an interdisciplinary team of computer science, user experience (UX), and education researchers for the development of a web-based 3D Interactive Virtual Training Environment for Teachers (IVT-T). IVT-T aims at simulating students' disruptive behaviors in a virtual classroom, to provide teachers practice with problematic students, as well as to give them constructive feedback and reflection opportunities about what they experienced during the practice sessions.

The development of IVT-T has been spread over 4 years, with an increasingly sophisticated prototype refined each year, based on iterative evaluations. The IVT-T software includes four separate subsystems: 1) the 3D graphics environment (30 virtual students and 2 classrooms of different age groups); 2) the simulator controlling the behaviors of the virtual students (including four disruptive protagonists) and objects in the classrooms; 3) the IVT-T back-end controlling the system functionalities; and 4) the IVT-T website and its user interface (UI).

To manage the design and development of these four distinct (yet communicating) components, we adapted Hartson and Pyla's approach [4] by structuring the system's overall lifecycle into three parallel iterative lifecycles: the 3D *graphics design* lifecycle, the *user* *experience design* lifecycle conducted with the education team, and the *software engineering* lifecycle conducted with the UX team. The development of IVT-T 1.0 also included a separate track led and conducted by the team of education experts to write vignettes specifying the speech contents and disruptive behaviors to be simulated for two types of students, namely off-task or aggressive [11].

2 RELATED RESEARCH

ClassSim is an online 2D low realism storyboard-based simulator that focuses on 3 types of behaviors: bullying, behavioral difficulties (agitated or reserved), and non-native English speakers [5]. Pre-service teachers make decisions on classroom layouts, on the order of classroom activities, and can make behavioral management decisions. Teachers interact by clicking through 2D still pictures of cartoon-like students in the classroom, from scenarios established by teachers' own experiences.

SimSchool simulates a classroom with up to 18 low fidelity 2D cartoon-like students [13]. Students' behaviors are driven by a model calculating virtual students' learning when attributed a task or when interacted. *SimSchool*'s students display 3 different physical postures, and utterances are cartoon bubbles (although how the system controls their communicative behaviors is not fully described). An evaluation showed that some teachers, however, found limitations in the realism and plausibility of students' responses [1]. Additionally, the graphics were not evaluated in this system.

VirtualPREX [3] is an online 3D classroom simulator developed in Second Life *(http://secondlife.com)*, which is a 3D world in where users are represented by avatars. Avatars are controlled by selecting action from a set of animations and by live-chatting. The 3D environment consists of 4 classrooms (10 students per classroom). Via their avatars, *VirtualPREX* teachers practice by interacting with avatars controlled by other trainees following pre-scripted scenarios. Scenarios were developed by 8 experienced teachers and portray 4 behaviors: on-task active or passive, off-task active or passive. A limitation is that trainees cannot practice on their own, they need other trainees to control other virtual students, and authors observed they lost interest in participating.

TLE TeachLive [2] presents teachers with a life-like, wall projection of a 3D classroom with 5 students. A human acting as a hidden Wizard of OZ (WOZ) is needed to control both a student's actions (according to that student's given history and personality), and the student's body animations. Limitations of *TeachLive* are that it requires a human to operate the system, only one student at a time can be simulated, the human must remember each student's history and personality to accurately control the student, and live recording requires special equipment to control students' animations.

Lugrin et al. [6] implemented the *Breaking Bad Behaviors (3B)* classroom simulation system, in which users wear a Head Mounted Display (HMD). The virtual classroom contains 24 virtual students, with 6 disruptive behaviors types (from null to extreme) and 20 utterances (from generic to advanced). *3B* also requires a WOZ human instructor to follow a set of instructions to control a student by selecting a disruptive action and/or a sentence. The WOZ instructor observes how pre-service teachers react and can adapt the simulation by selecting among different levels of disruptive behaviors and by providing direct feedback.

Original requirements	Topics
Vignettes depth: 4 to 5 minimum choices and 7 to 9 maximum choices.	Vignette Content
Vignette endings: 3 possible endings regardless of number of paths traversed.	
Randomize student disruptive behaviors to maximize generalization of teachers skills.	
Three difficulty levels (Basic: take as much time as you like; Intermediate: timed decisions; Advanced: timed with background noises).	Training Sessions
Training phases: (1) Practice, (2) Playback while reflecting on side document, and (3) Feedback.	
Teachers have 20-30 seconds to make decision.	
Vignette progression: No pausing during vignette practicing. If trainee quits before end, has to start from beginning.	
Classroom academic level should be accessible according to provided lesson plan.	
Introduce disruptive students behaviors on first practice.	
Logbook: Trainees actions during each IVT-T practicing session so that trainees can review what they did on prior sessions.	
Teachers should be able to tour the empty classroom (classroom with no kids).	
Tracking logs (no further details).	
Display word and play audio of virtual students and only display text for teachers.	User Interface
Students should wear uniforms: Light blue long sleeved polo shirts and khaki pants.	3D Environment
Students: 15 first graders and 15 sixth graders.	
Students appearance should reflect demographics of NJ high poverty schools: equal mix of African Americans and Latino/a.	
Students should be animated.	
Students response time should be less than 5 seconds.	
Trainee perspective: Trainee has a first person view.	

Table 1: Initial requirements organized by topics.

Although a few systems have started to provide some virtual training for teachers [2, 3, 5, 6, 13], there is not an accepted list of functional or user experience requirements. Moreover, presently there are not requirements pertaining to the graphical realism of the students or environments. Finally there are no evaluation methodologies currently used to drive the successful implementation of simulation-based VLEs for teachers.

3 SYSTEM REQUIREMENTS

The first step towards the implementation of the IVT-T 1.0 prototype was the analysis of the requirements provided by the educational experts (reproduced in Table 1), by the computer science team. However, the requirements given were incomplete and required many iterations between the UX team and the domain experts, and between the UX team with the software engineers, to arrive at a stable (yet still evolving) set of functional and UX requirements.

For example, domain experts had not determined what information to include in the trainee "logbook" originally conceived to gather and display data items such as amount of time played, levels reached, classroom and virtual students practiced with. Designing alternative prototype sketches of the UI with all these items helped domain experts to realize that providing so much data would lead to trainees' cognitive overload. After many iterations of sketching, the "logbook" (renamed as "tracking log") content was finalized to include: time practicing for each behavior, summary of each storyline with associated scores and feedback, and remaining practice sessions before leveling up. Similar iterations were conducted to establish and refine the following set of requirements, which we suggest as desirable for the development of future VLEs for teachers, and ordered by categories:

(1) Content: vignettes, feedback, reflection themes, student bios, and scores;

(2) Content Delivery: sessions sequenced in practice, replay, reflect, and feedback phases;

(3) Display to Users: first person view, access to pedagogical resources, previous log of simulation;

(4) User Data: track of logs and scores;

(5) Representational Fidelity: realism of virtual students graphics: face, body, hair, clothing, proportions, child-like appearance, reflecting age; realism of virtual classrooms graphics: furniture, objects, furniture placement; realism of behaviors: students' behavior/dialogue based on grade and presenting behavioral problem, teachers' responses based on grade and presenting behavioral problem; match between 3D graphics and behavior realism.

4 IVT-T

Establishing requirements helped to organize the development of IVT-T while addressing limitations from previous systems.

A conceptual model established by the software engineering team brought to life twelve vignette scenarios, scripted by the education team, describing teachers and virtual students interactions. Unlike most existing systems requiring humans to puppeteer the behaviors of virtual students, IVT-T automatically generates students' behavior from the scenarios. This ensures both scalability and autonomy. Moreover the online development of IVT-T guaranteed its accessibility (available 24/7 from a computer).

Education domain experts also provided requirements regarding the training delivery, composed of 3 ordered phases: practice, then reflection, then feedback. Feedback is used in many existing systems and helps teachers adapt to new situations, and change their approach to improve their performances [2, 6]. Reflection, only used by one classroom simulator, have been showed to increase learning and transfer when integrated into the instruction [10]. IVT-T encourages teachers to reflect about situations they face in the simulations with thematic questions.

By tracking teacher trainees' data, via the tracking log, IVT-T offers teachers the opportunity to visualize their training evolution. Additionally, tracking logs are also a way to adapt the scenarios difficulties to the trainees' level of expertise by allowing access only to certain level if some objectives are not reached.

Finally, the design and implementation of IVT-T 3D environment was completed via a lifecycle of requirements-design-prototype-evaluation of its own [4]. Various features were included to provide authenticity when developing the 3D graphics for the virtual students and for the classrooms. Great care was taken to ensure realism, and several iterations were needed to develop the appearance during the requirements phase, design phase, and evaluations. The details of the characters and the objects in the environment, e.g. layout of the desks and age-appropriate hairstyles, ensured high fidelity for actual schools to present the most immersive experience possible [11].

5 CONCLUSION

This article described the collaboration between a team of educational experts, design specialists, and software engineers in the development of a 3D VLE to support teachers' training. Through this work we sought to improve upon existing systems, as well as to define requirements systematically for IVT-T.

Prior work on education-based VLEs revealed that no functional, non-functional, and UI requirements previously existed to drive the successful implementation of simulation-based VLEs for teachers. We briefly described the iterative process used by our interdisciplinary team to establish, organize, and prioritize the requirements that would allow all the teams involved to work together to establish the first version of IVT-T. Through definable goals and expert evaluations of prototypes during the process, we created a system to help ECTs get the training they lack.

Future versions of IVT-T will continue to build on this initial work, and in addition, the process employed may serve as a model for development of other VLEs that could help users to improve their social skills.

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