The Effects of Instructional Simulation Use on Teaching and Learning: A Case Study

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This article describes a case study of how a simulation used in an Audiology course changed the way the instructor taught and how students learned. We combined the perspectives of West & Graham[1] *and Roschelle, et al*[2] *as a framework to analyze the data. We found that in at least some ways use of the simulation improved: the students' ability to visualize procedures and concepts, the quality and quantity of practice, the level and authenticity of student engagement their learning, the interaction and collaboration among students and the students with the instructor, and the opportunities for reflection in-practice and on-practice*[3].

Keywords Instructional Simulations; Educational Technology; Higher Education; Audiometery

1. Introduction

We have seen a significant increase in usage of and interest in simulations to enhance instruction in higher education. With the rise in interest and usage of computer-based instructional simulations, the question arises: How are simulations helping to improve teaching and learning? Much of the literature on instructional simulations either reports quantitative results of how much (or how little) simulations help students learn while other literature discusses theoretical views on the use of simulations. For example, Lieberth & Martin[4] reported on the effectiveness of an online simulated audiometer. However, little research has been done to show how simulations affect the dynamics of teaching and learning, especially from the perspective of the instructor and the students.

We used a case study approach to try and better understand these dynamics and how the use of a simulation changed the way the instructor taught and students approached their learning. The case we studied was the use of a "Virtual Audiometer" in an introductory course in Audiology focused on teaching students to conducting hearing tests. The Virtual Audiometer is a simulation created at Brigham Young University (see Figure 1). The program allows students to administer hearing tests to a variety of virtual patients. A set of virtual patients comes with the program, but instructors can create new patient profiles for use by their students. The simulation is used in class for demonstrations of procedures and out of class for student practice. Students' learning is also assessed during the final exam using the Virtual Audiometer.

Previous to using the Virtual Audiometer, the professor had tried a few different methods for demonstrating procedures in class using a portable audiometer, including video cameras. However due to the large number of students in the course it was usually difficult for students to clearly see what he was doing. For homework assignments, students would pair up and test each other on these same portable units. Testing on the portable units had its benefits, i.e., students received hands-on experience using real audiomtery equipment, However, testing other class members made it difficult to simulate authentic hearing impairments.

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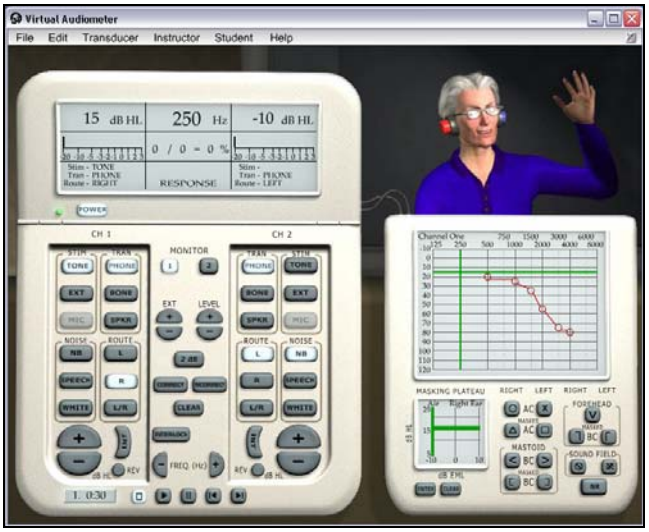

Fig. 1 *Virtual Audiometer Interface*. The Virtual Audiometer with a female geriatric patient loaded. The program has both male and female child, teen, adult, and senior patients with the potential for a nearly infinite number of profiles.

2. Review of Literature

Simulations have often been compared with other instructional methods in order to identify their comparative instructional effectiveness and impact upon the learning approach. Several advantages and limiations of instructional simulations have been discussed in the literature. Among the advantages, simulations have the potential to do the following: (1) improve teaching aims and methods[5] [6] [7] [8]; (2) improve learning and practice[6] [9] [10] [11] [12]; (3) motivate students[13] [6] [14] [15]; (4) save operational cost and time[5] [9] [1]; and (5) increase safety[9] [1]. Two of the main barriers or limitations to the use of instructional simulations cited are: (1) capital costs and time constraints[6], and (2) technical barriers, especially teachers with limited computer skills [6].

More generally looking at the potential for educational technology to improve teaching and learning, the following themes emerged from the work of Roschelle, et al.[2] and West & Graham[1]: (1) Visualization: Use of technology should help illustrate visually to the students the theory behind the technique[1]. (2) Authentic Engagement: Students should be actively engaged in the learning process rather than passive receivers of knowledge[2] and engagement is more meaningful if it is authentic (i.e., similar to real-life experiences)[1]. (3) Quality and Quantity of Practice and Feedback: Technology can be used to provide more and higher quality practice opportunities [2][1]. (4) Interaction and Collaboration: Technology can be used to provide students the opportunity to interact with each other or with the instructor[1]. (5) Reflection: The use of technology should "support meaningful student reflection"[1]. Schön[3] discussed two types of reflection: "reflection-on-action" which is when a person reflects back on actions they have take in the past and "reflection-in-action" which occurs when a person reflect on their actions as they are in the midst of performance or decision making.

3. Methodology

We collected data through an in-depth interview with the instructor supplemented by several brief follow-up interviews. We also conducted nine classroom observations and observed 20 students use the simulation to complete assigned patient cases out of class. At the end of the semester, students (N=44) responded to an opened-ended survey.

To analyze the data, the team used a constant comparison methodology. We combined the perspectives of West &Graham[1] and Roschelle, et al.[2] as a framework to analyze the data. As we collected data, we met together to discuss new findings and look for trends. We met together several times throughout the course of the study to discuss the cases and implications of what we were finding in our data. We also triangulated data from the various sources of data to assure that our data was reliable and our conclusions were valid. We also ran member checks with the instructor in the case and conducted peer debriefs with colleagues.

4. Findings

As we analyzed the data we had collected, we found that the use of the Virtual Audiometer simulation functioned as a catalyst in enhancing teaching and learning according to the five characteristics described earlier. In some situations, though, we found that with some modifications to the implementation that these characteristics could be further enhanced. We will discuss how this occurred for each of the five themes.

4.1 Visualization

A large portion of the students reported that an advantage of the Virtual Audiometer was that it helps them to visualize course content in at least three ways. First, the Virtual Audiometer was shown in class via projector, which allowed students to see exactly what the professor was doing. One student commented, "We were able to see what buttons he was pushing and what frequencies he was testing…A wonderful way to present to a class this size." Second, the instructor could select cases that were specifically useful to get across a particular concept related to hearing loss. Because of this student practice was not limited by access to individuals with particular hearing disorders; all students could gain practice diagnosing all important hearing conditions. One student reported, "using Virtual Audiometer helps to see how specific hearing losses look…" This was helpful not only for in-class demonstrations, but for the selection of cases for student practice. Third, the professor helped create a new interface for recording the resulting audiogram (see figure 1). The students seem to benefit from seeing an audiogram created before their eyes. One student reported that "without [the Virtual Audiometer] we wouldn't have been able to visualize how the procedures worked…If we were just shown pictures of completed audiograms it wouldn't have been as effective."

4.2 Authentic Engagement

Although the use of real audiometry equipment might seem more authentic, the use of more authentic cases availalbe in the simulation for in-class demonstrations and for practice out of class seemed to contribute more to the students' understanding of the underlying concepts of hearing loss. Before the implementation of the simulation, students would attempt to imitate hearing loss by wearing earplugs when they were being tested. This practice proved less than satisfactory, however, it was nearly impossible to recruit persons with the right kinds of hearing loss even for in-class demonstrations, let alone recruiting the number of people that would be needed for students to practice. However, with the Virtual Audiometer, the instructor could select or create more authentic cases for in-class demonstrations and for student practice.

With the ability to do more demonstrations in class, the professor was able to solicit input from the students on how he should proceed during demonstrations as well as discussing the meaning of what he was doing and the results of the test.

Another aspect that students reported enjoying was that the demonstrations often led the professor to share anecdotes from his professional practice. One student mentioned that the professor's use of the

Virtual Audiometer in class "helped me get an idea of how audiometry is done. He would explain what is done clinically. I enjoyed hearing about a couple of experiences [he had] doing audiometry."

4.3 Quality and Quantity of Practice and Feedback

Previous to using the Virtual Audiometer, students couldn't always see what the profeossor was doing and thus had difficulty following along with the in-class demonstrations. Therefore, it was difficult for the professor to include students in the process. And thus the opportunities for guided practice as a group were limited. After implementing the Virtual Audiometer, however, students were better able to see each action the professor was taking and follow the procedure he was using to complete hearing tests. One student reported that "example practices in class were helpful."

Prior to using the Virtual Audiometer, when students tested each other, the professor really had no way to assess how well the students were doing besides trying to observe all the students (which would be difficult in a class of 40-50 students). However, with known patient profiles, the professor can provide students with a variety of cases and can easily assess their results. Despite the professor's ability to assess students' performance, one of the students' main requests was for more feedback.

The Virtual Audiometer also facilitates a higher quantity of practice opportunities since students can use the simulation anytime or anywhere. When the students used the portable audiometers, the number of units availalbe and the logistics of checking out the units limited the number of practice opportunities.

4.4 Interaction and Collaboration

Prior to using the Virtual Audiometer, it was more difficult to get the students involved in in-class demonstrations. However, because the use of the Virtual Audiometer allowed the professor to more easily demonstrate procedures in class it has freed him to invite students to participate in the demonstration process. Students appreciated this, yet they reported wanting to be even more involved in the in-class demonstrations.

Although typical use of the Virtual Audiometer did not promote much interaction and collaboration among the students outside of class, we did observe a pair of students who used the Virtual Audiometer collaboratively. These two students would each complete hearing tests up to a certain point then compare results and discuss discrepancies or confirm each other's work. So if encouraged, the simulation could be the catalyst for meaningful collaboration and interaction outside of class as well.

4.5 Reflection

Prior to using the Virtual Audiometer, there was more of a focus on teaching facts and procedures. With the implementation of the Virtual Audiometer, the professor said that students were learning the procedures more quickly which gave him more time modeling reflection-in-action (Schön, 1987) by discussing the procedure and reasons for taking certain steps and some reflection-on-action (Schön, 1987) as he discusses the results of the test with the class. This also helped students to think about what they were learning at a higher level (i.e., starting to reflect-in-action). One day, the professor commented that he was getting questions of a different nature. He later clarified that students used to be more concerned with the mechanics of what he was doing and now he is getting more questions dealing with why he is doing what he is doing and what the results mean.

Prior to using the Virtual Audiometer there is no record of students doing reflection as part of their out-of-class practice. According to the professor, more time was spent just trying to learn the procedures. With the Virtual Audiometer at least some students reported spending time analyzing the results of the

virtual cases, although reflection was not specifically encouraged. Since the use of the Virtual Audiometer provides more opportunities to practice with more authentic cases, with some encouragement it could further even more opportunities for reflection both in and on action.

5. Conclusions

We found that in this case, the use of an instructional simulation helped to enhance the teaching and learning environment in the five ways suggested: Improved visualization, enhanced authentic feedback, enhanced quality and increase quantity of practice and feedback, increased amount and quality of interaction and collaboration, and increased and enhanced reflection. However, this did not occur in every situation (for example, there was less interaction and collaboration between students on out-of-class assignments). Yet with modifications to the simulations implementation even these weaker areas could be strengthened.

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