Assessing the Impact of a Virtual Lab In Health Care Education

Helene Goulding
Senior Lecturer
Faculty of Health Sciences
University of Ontario Institute of Technology
Oshawa, Canada
helene-marie.goulding@uoit.ca

Robin Kay
Professor
Faculty of Education
University of Ontario Institute of Technology
Oshawa, Canada
robin.kay@uoit.ca

Jia Li
Assistant Professor
Faculty of Education
University of Ontario Institute of Technology
Oshawa, Canada
Jia.Li@uoit.ca

Abstract: The purpose of this study was to investigate the effectiveness of an online virtual lab as a learning tool to prepare allied health students for face-to-face laboratory sessions. Both qualitative and quantitative data were collected from 64 university students (55 females, 9 males) and analyzed to assess attitudes towards the virtual lab. Students reported that the virtual lab made skill acquisition easier and faster, helped them prepare for hands-on laboratory sessions, and was a tool they would use again. The key benefits of the virtual lab was that it enabled students to visualize procedures and reactions outside of the traditional laboratory setting. Student visualization enhanced preparedness and performance in the laboratory environment.

Introduction

For long-term benefits to be obtained from hands-on laboratory experiences, students must be theoretically and procedurally prepared (Gregory & Di Trapani, 2012). Previous research suggests that students do not prepare well for laboratory work (e.g., Ealy & Pickering, 1992; Jones & Edwards, 2010; Pogacnik & Cigic, 2006; Whittle & Bickerdike, 2015). Jones and Edwards (2010) reported that only 15% of undergraduate biology students (n=128) did substantial preparation, while 85% did some or no preparation. Pogacnik and Cigic (2006) found 20% of their undergraduate chemistry students (n=223) did no preparation at all.

Poorly prepared students may experience cognitive overload as they attempt to learn hands-on skills and theoretical concepts simultaneously (Gregory & Di Trapani, 2012; Jones & Edwards, 2010). If students focus on the practical competencies in a lab, they may fail to make the correct observations and consequently may be unable to make connections between the laboratory experience and theory (Johnstone & Al-Shuaili, 2001; Jones & Edwards, 2010). Pre-laboratory exercises may reduce cognitive load and allow students to observe and make conceptual connections better.

It has also been argued that hands-on, phsycial laboratories may not provide an optimal learning experience (Rollnick et al., 2001). Physical laboratories require extensive time and materials to operate (Gibbons et al., 2004) and have rigid teaching schedules (Flint & Stewart, 2010). Laboratory skill training is expensive (Lombardi, 2007; Tuysuz, 2010) and can only accommodate small groups (Lehmann et al., 2013; Tuysuz, 2010). With monetary constraints for supporting traditional educational laboratories, there exists a real need to find less costly alternatives

(Baker & Verran, 2004). Gibbons et al. (2004) noted that if the manipulation and interpretation of data are the primary learning outcomes, then virtual laboratories can provide a more economical, easier, and less time-consuming alternative. Virtual laboratories are also regarded as a safer alternative than traditional hands-on laboratory sessions (Baker & Verran, 2004; Lewis, 2014; Scheckler, 2003).

While virtual learning environments have been adopted for health care education in medicine, dentistry, and nursing, there is minimal literature regarding its use in allied health education (Butina et al., 2013). Butina et al. (2013) reported that 84.6% of allied health programs that do not currently use virtual learning environments and would be interested in doing so. Baker and Verran (2004) added that it is important for allied health students to be exposed to as many different scenarios as possible to become more efficient in clinical diagnostics and that virtual laboratories may allow for this enriched exposure.

The purpose of this study was to examine the perceived benefits, challenges and impact of a virtual lab designed to support university students for face-to-face laboratory sessions.

Method

Participants

The participants consisted of 64 students (55 females, 9 males) sampled from a total population of 97 undergraduate allied health students in a Canadian University, for a response rate of 66%. Students were enrolled in the second (n=35), third (n=17), or fourth year (n=12) of a medical laboratory science program. Sixty-seven percent of the students (n=42) reported that they were native-English speakers. Thirty-one percent (n=23) of the students were between 17-20 years old; 36% (n=23) were 21-24 years old; 19% (n=22) were 25-29 years old; and 14% (n=9) were over 29 years old.

Virtual Lab

The virtual lab was used as a supplementary pedagogical tool in clinical microbiology courses with both hands-on and theoretical laboratory components. The virtual lab was available, via the Internet, to all students enrolled in the courses and was designed to promote the mastery of a broad array of procedures and bacterial nomenclature. The virtual lab, which mimicked algorithmic bacterial identification procedures performed in a clinical microbiology laboratory, included procedural videos and images of expected reactions. It enabled students to view and review expected results before the hands-on laboratory sessions. The intent was that procedural mimicking would reduce students' cognitive load during hands-on laboratory sessions, thus resulting in better learning outcomes.

Data Collection

The online survey used for this study contained 14 seven-point Likert scale questions. The Likert survey was used to determine students' attitudes towards using the virtual lab for laboratory preparedness and the perceived impact on the development of their practical skills. Three items were related to student learning with the virtual lab, three items referred to the design elements of the virtual lab, and eight items referred to the perceived impact of the virtual lab. Six open-ended questions were used to ask students about the benefits and challenges of using the virtual lab and changes that might be made to improve the learning experience.

Procedure

A pre-laboratory checklist explained the requirements for each hands-on laboratory and directed students to the particular components in the virtual lab. Students were advised that completing the pre-laboratory activities and using the virtual lab was voluntary and no extrinsic motivational factors such as assessments or grades would be associated with participation. From week one to week 13 of the course, the virtual lab was integrated into weekly activities that included traditional lectures and hands-on laboratory sessions. At week 10, students were sent an email inviting them to participate in the online survey. Sixty-four students filled in the survey for a response rate of 66%.

Results

Benefits of Virtual Lab

The means for the virtual lab benefit items ranged from 5.9 to 6.6 on a seven-point Likert scale (Table 1). The scores suggest that most students agreed that the virtual lab was easy to use, provided images and videos that helped them learn, presented a useful checklist that helped them prepare for hands-on laboratory sessions, offered a helpful layout for bacterial identification, and provided helpful feedback.

Table 1 - Student Ratings of Virtual Lab Benefits

Item	*M*	*SD*	Disagree	Agree
Images helped me to learn	6.6	0.6	0%	97%
Videos helped me to learn	6.4	0.9	0%	86%
Pre-lab checklist exercise helped me prepare for labs	6.4	0.9	2%	81%
Was easy to use	6.2	1.1	3%	86%
Offered helpful layout for bacterial identification	6.2	0.9	0%	80%
Provided helpful feedback	5.9	1.1	2%	75%

Students offered 159 comments about the benefits of using the virtual lab. Seventy-five percent (n=119) of the comments focused on learning, 18% (n=29) referred to the design of the virtual lab, and 7% (n=11) targeted engagement. Key learning benefits cited by students included visual supports (n=46), authenticity (n=32), learner control (n=17), and helping them to understand (n=12) and remember concepts (n=11). Key design features identified as beneficial included the overall organization (n=16), graphics (n=5), ease of use (n=5) and interactivity (n=3). Finally, engagement benefits included the virtual lab being a better alternative to a reading-based format (n=6) and increasing confidence (n=3).

Challenges of Virtual Lab

Thirty-nine responses were collected from students regarding challenges of using the virtual lab. Most challenges were related to learning (n=22) or the design of the virtual lab (n=14). With respect to learning, lack of learner control (n=8), difficulties in understanding the material (n=6), and missing content (n=5) were the most challenging for students. Learner control issues included not being able to skip forward to the end and the inability of the program to save the students' progress. Regarding understanding, some students noted that they did not understand the material well enough to use it effectively. Finally, regarding missing content, a few students remarked that the virtual lab did not include all tests and organisms.

For design challenges, organization issues (n=9) were the most common. For example, some students disliked not being able to retrieve information quickly and being required to go through entire identification pathways. Other students found the pathways confusing at times and had difficulty navigating.

Perceived Impact of Virtual Lab

The mean scores Likert scale items assessing the perceived impact of the virtual lab ranged from 6.1 to 6.7 on a seven-point Likert scale (Table 2) suggesting that university students believed that the virtual lab had a positive impact on preparation for the face-to-face laboratory sessions.

Table 2 - Student Rating of the Perceived Impact of Virtual Lab

Item	*M*	*SD*	Disagree	Agree
I would use the virtual lab again	6.7	0.7	0%	95%
Viewing procedures ahead of time was helpful	6.6	0.7	0%	97%
It helped me to prepare for labs	6.4	1.1	3%	91%
It helped me achieve greater success in learning	6.1	1.0	2%	84%
It made it was easier to learn new skills	6.1	1.0	0%	78%
It helped me develop skills faster	6.1	1.1	2%	77%

The open-ended questions produced 69 responses from students regarding the key characteristics of the virtual lab they thought were most beneficial in helping them acquire new skills. The visual components (images and video) were identified as helpful (n=36) as well as the organizational design (n=11).

Discussion

Triangulation of the data in this study suggested that the overall attitudes of undergraduate allied health students toward the virtual lab as a tool for facilitating pre-laboratory preparation were positive. The categories which students rated highest included visual learning, authenticity, learner control, and organizational design.

Students struggle to visualize laboratory expectations from written or verbal instructions (e.g., Jones & Edwards 2010). The results of the Likert scale and open-ended responses indicated that the greatest benefit of the virtual lab was the ability for students to visualize results and procedures outside the traditional laboratory, which is not surprising as the literature suggestss that the majority of students prefer visual learning resources (e.g., Lehmann et al., 2013) over traditional written laboratory manuals (e.g., Gregory & Di Trapani, 2012; Jones & Edwards, 2010).

Authentic learning is not restricted to traditional laboratory work (Lombardi, 2007). Carefully designed virtual reality learning environments may provide students with real-life laboratory scenarios. While the authenticity of the virtual lab was not included as a Likert scale item, this category had the second highest number of comments (n=32) from the open-ended questions on the benefits of the virtual lab for preparing for laboratory classes. This result contradicts Scheckler's (2003) perspective that virtual laboratories do not embody the reality of the hands-on laboratory. However, the results are consistent with Lombardi (2007) who noted that a virtual laboratory might help students apply knowledge to new situations, thereby providing authentic learning.

The literature supports the importance of students being able to control the learning process (e.g., Gibbons et al., 2004; Issenberg et al., 2005; Ruiz et al., 2006). The learner control category was not included as a Likert scale item. However, the third highest number of comments (n=17) from the open-ended questions referred to student ability to learn independently at their own pace, when and where they wanted.

Triangulation of the data indicated that students found the design elements of the virtual lab to be beneficial. From the Likert scale survey and open-ended questions, students reported that the virtual lab was easy to use. This result is consistent with Limniou and Whitehead's (2010) research on the importance of online resources being easy to negotiate. If students can access information quickly and easily, they are more likely to use and enjoy the pre-laboratory resource (Flint & Stewart, 2010; Limniou & Whitehead, 2010).

Though virtual laboratories may overcome many of the constraints of physical laboratories (Johnson & Gedney, 2001), they come with their own inherent limitations (Lewis, 2014). Students reported some challenges concerning the organizational design of the virtual lab. Though the organizational design of the virtual lab was rated highly as a benefit (80%), it was also viewed as a challenge for some students in the open-ended questions (n=9). Flint and Stewart (2010) reported similar results with their virtual lab in which organization received the highest rating as both a benefit and a challenge. Flint and Stewart (2010) suggested that a short training exercise prior to use would be beneficial. The virtual lab in this study did have a navigation tutorial; however, given the results of this study, it may be useful to perform a careful review of this resource.

While learner control was reported as a benefit in the open-ended questions (n=17), it also was reported as a challenge for some students in the open-ended comments (n=8). The same design feature can be seen as a benefit to some and a challenge to others. For example, Flint and Stewart (2010) said that although students reported their virtual laboratory exercises to be well mapped, they cited navigation and screen layout as areas for improvement.

Regarding perceived impact, student attitudes towards the virtual lab as a resource for both laboratory preparation and increasing performance were positive. The virtual lab enabled students to become familiar with tasks before hands-on laboratory sessions and provided helpful visual supports. The virtual lab may have affected performance by decreasing cognitive load in the hands-on laboratory, thereby allowing students to acquire new skills faster and easier and aiding in completing the hands-on laboratory sessions. Over three-quarters of the students reported that the virtual lab made it easier and faster for them to develop and learn new skills. This finding is consistent with Jones and Edwards (2010) who found that student performance improved when educational tools supported their learning preferences. Sancho et al. (2006) also found that students gained competence using a virtual lab.

Limitations and Future Research

There are several limitations of this study that should be noted for future researchers. First, the sample population was relatively small and lacked complexity. More research needs to be conducted on a diverse population from a wider range of allied health programs to determine the generalizability of the results. Second, the Likert scale could be expanded to include challenges to using virtual labs, authenticity, learner control, and content items. Third, the Likert scale needs to be improved in terms of reliability and validity. Finally, future analysis could be enhanced by comparing the actual performance of students who used and did not use virtual labs to prepare for face-to-face laboratory sessions.

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