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Employer and work-based student perceptions of virtual laboratory teaching and assessment resources

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Training in laboratory competency is an important part of biomedical student skill acquisition in preparation for both the workplace and accreditation. Virtual laboratory simulations are currently used in core modules at University of Westminster to prepare biomedical science students for laboratory sessions. These simulations are used for formative and summative assessment and incorporate questions on theoretical aspects, in addition to simulating laboratory techniques. Whilst analysis has been carried out on student learning with virtual laboratory simulations, the impact of these on work-based students and the opinions of employers has not been evaluated.

Students undertaking core first year modules include part-time attendance work-based students and part-time distance learners, who are mostly employed in diagnostic laboratory settings. Part-time work-based students and distance learners often need to be more efficient and maximise their use of available study time than their full-time student peers. The aim of this study was to collect the views of the work-based students and their employers on these virtual laboratory simulations through semi-structured interviews to evaluate the effectiveness of these teaching tools for work-based students.

This report presents the comments of part-time students, distance learners and employers relating to the use of virtual laboratory simulations highlighting key similarities and differences. The consensus is that use of the virtual laboratory is helpful and can supplement but not replace practical classes and employer-led training. At present there is no appetite amongst employers to use these simulations to replace competency testing. Whilst virtual laboratory simulations are recognised to have benefits, there are caveats related to both cost/ benefit and to how they should be deployed.

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Introduction

University of Westminster has a long association with the education of prospective biomedical scientists at both undergraduate and post graduate levels. In addition to full time undergraduate courses, two part-time undergraduate biomedical science courses are offered, the part-time day-release BSc Applied Biomedical Science and Foundation Degree in Biomedical and Physiological Sciences, which is a distance learning course. The BSc Applied Biomedical Science course is approved by the Health and Care Professions Council (HCPC), accredited by the Institute of Biomedical Science (IBMS) and the Royal Society of Biology; the Foundation Degree in Biomedical and Physiological Sciences is approved by the IBMS. HCPC approval and IBMS accreditation enable successfully completing students to apply for registration as biomedical scientists.

Students studying part-time are employed in diagnostic pathology laboratories as trainee biomedical scientists, associate practitioners or medical laboratory support workers. They are employed in single discipline or multidisciplinary settings and hence have day to day experience in one or more of the fields of clinical biochemistry, cellular pathology, haematology and blood transfusion, clinical immunology or medical microbiology. Within their employment they undertake tasks that employ a selection of manual techniques and use a range of automated technologies.

The University of Westminster works in partnership with the student employers for both these part-time courses. Credit-bearing work-based learning modules allow input from employers having the role of work-based tutors with respect to setting and marking of assessments. Local training for the work-based learning module requirements is provided for the work-based tutors. Additionally, regular employer liaison meetings and an annual Employers Day ensure employer and university updates are available and views are sought for new initiatives and developments. As part of the first year these students attend Biochemistry, Cell Biology and Human Physiology with the other Life Science students at the University as well as modules unique to their courses: Critical Skills for Biomedical Sciences

and Functional Anatomy. These modules are delivered in two modes: attendance and distance learning.

Pedagogical approaches which incorporate virtual simulations are based upon constructivism theory involving experiential student learning, as well as, learning in safety (Starĉiĉ, 2008). Virtual simulations have been used in a wide range of disciplines to prepare students for specific skills in science (Pyatt & Sim, 2012), engineering (Potkonjak *et al.,* 2016), medicine (Hviding *et al.,* 2009) and nursing (Liaw *et al.,* 2018). The use of such simulations in the work place can have diverse aims amongst which commonly cited are for team training or to mimic a scenario (Liaw *et al.,* 2018).

In this study, in order to prepare students for practical laboratory sessions, virtual laboratory simulations were introduced to teaching. The first virtual laboratory simulation was provided by a company Labster™, here the participant is in a virtual laboratory where they must carry out simulated laboratory skills, the students need to answer questions to progress through the simulation and typically completion of a simulation is 15-20 minutes. The second type of simulation available to students was part of the LearnSmart™ laboratories produced by McGraw-Hill, here the simulations form part of a portfolio which involves case stories, tests, reading and videos, completion of which integrates with the student's virtual learning environment and is credit bearing.

Aims and Objectives

Aim: To evaluate the perceived benefit of virtual laboratory simulations from the perspective of work-based students and employers

Objectives

1. To collect views from employers about the use of virtual laboratory simulations used to teach first year students
2. To collate feedback about the simulations from students already employed in the workplace studying in part-time mode
3. To collate feedback about the simulations from students already employed in the workplace studying as distance learners.

Methodology

This project was based on a constructivist approach whereby the researchers collated qualitative research from semi-structured interviews with small groups; the questions used in the interviews had been pre-determined by the researchers in advance (Given, 2008), the interviews were designed with open-ended questions to allow participants to expand upon areas of interest but enabled the researchers to gain insight to specific aspects of virtual simulations and alignment to work based learning. The purpose of this qualitative methodology was for the researchers to describe and understand the effects of the virtual simulations rather than to predict and control the outcomes (Streubert & Carpenter, 1995).

Interviews were carried out with participants from three cohorts which were:

1. employers with training and or managerial responsibilities in diagnostic laboratories,
2. first year work-based students studying at University of Westminster part-time Applied Biomedical Science program
3. second year students at University of Westminster on a distance learning Biomedical and Physiological Sciences program.

This qualitative participatory action research aimed to collate data from the participants in order to evaluate the effectiveness of the virtual simulations for work-based students and employers (Greenwood & Levin, 1998) The researchers conducted semi-structured interviews with these groups (Morrison, 2013).

Methods:

Ethical approval: this study received approval from University of Westminster, Faculty of Science and Technology ethics board (application ETH1718-0079).

All interview participants were given an overview of the project and were asked to sign consent forms. The whole cohorts of part-time first year Applied Biomedical Science cohort (n=10) and the second-year distance learning Biomedical and Physiological Sciences cohort (n=10) were invited to the interview; both cohorts were studying the same modules which had included the virtual laboratory simulations. Both cohorts of students were also

undertaking the work-based learning modules of a biomedical science degree program. The whole of the part-time student cohort attended the interview (n=10), distance learning students (n=2 out of a cohort of 10) and employers (n=4) attended semi-structured group interviews based on predetermined questions. Employers had previously been given a demonstration of the Labster™ simulation and had been given opportunities to ask questions of academic teaching and Labster™ staff (June 2017). All responses were recorded and noted by members of staff and anonymised prior to analysis. The responses from the interviews were grouped into key emerging themes with key words incorporated into a Wordle. The positive and negative perceptions of use and usefulness of the Labster™ simulations were recorded.

Results

Employer questions:	Employer responses (n=4)
Have you viewed any virtual laboratory resources? Please provide details:	Most of the employers had only viewed the Labster™, which had been demonstrated previously at the University of Westminster Employers Day (June 2017) by Labster™, they did not have experience of the LearnSmart™ simulations. One organisation has its own in-house training resources and they develop and use their own systems.
Do you think these have a role in preparing students for employment?	"Yes, useful for core skills such as health and safety that are applicable to all settings".
Do you think these have a role in diagnostic laboratory training?	It was discussed that funding of such software would be an issue, but all would see this as complementing existing training. Most employers felt it would be a beneficial addition to the employment induction

	programme, some felt it could be used to complement face-to-face training by the creation of either scenario situations or the completion of risk assessments.
If yes to 3, how would you use such a resource? E.g. as preparation for competency assessment; to complement face-to-face training, to replace face-to-face training	In contrast employers did not think that virtual simulations should to replace face-to-face observation for competency assessment, but all felt there was certainly potential for this use of such systems to assist with and complement laboratory training. There was a suggestion that some elements that trainees complete alone could be made more interesting and interactive. Such a system would also need to be linked into the Training Management software and how this could be done would need to be considered.
Any other comments?	In addition to seeing the Labster™ simulations one participant had attended the Learning Technologies Exhibition at Olympia in January 2018 and commented on a virtual reality teaching platform that had been developed, considering that there was some potential around such software if costs were feasible.

Table 1: Results of employer interviews

Interview questions	Part-time work-based students n=10	Distance learning students n=2
Why did you use Labster™? Was it for revision/ preparing for practicals / preparation for lectures or labs?	50% to prepare for practical 60% for revision 40% to supplement lecture notes	Used to support the other study materials to reinforce learning. It provided additional background theory,
Why didn't you use it?	n/a	n/a
Which aspects appealed to you?	The simulations provided a rough outline of practicals. Good opportunity to understand theory in context of practical.	The content was good
Were there aspects which didn't appeal?	There were some issues with screen resolution and browsers. There were frustrations in the Labster™ simulation where it was unclear where to click in the virtual lab in order to progress. Sometime the built-in questions which needed to be answered to progress through the simulation did not have enough and so other sources were also needed.	No negatives about content. The simulations were slow to run, not free flowing and can take a long time. One student tried to complete the session in a workplace lunchtime, but the system was too slow.
How do the Labster™ simulations align to actual laboratory techniques	The theoretical information linked to the applications with	Both students were happy with this and thought the alignment was good.

used (either in the University or the workplace)?	some benefits in providing perspective. Some of the questions in the simulation went in to too much detail and at other times not enough detail.	
Do you find that the Labster™ simulations support the given lecture material and the theory of procedures?	Yes – generally Labster™ good for theory	Yes, as stated in Q 1
Do you have any other comments?	Students highlighted that there were some technical issues setting up both the Labster™ and LearnSmart™ simulations.	No
Do you think that the scores from the Labster™ simulations would be an appropriate assessment tool?	Good for formative but not summative assessment.	Perhaps not for summative assessment because of technical issues, but OK if more than one attempt was allowed.
If the Labster™ simulations were assessed would you have been more likely to do them?	n/a All of the students had completed the simulation.	Mixed response (both students has completed the 6 simulations which were available), other distance learning students reported log-on problems.
Have you used any other virtual laboratory	McGraw-Hill and LearnSmart™	Yes. McGraw-Hill for the Functional Anatomy

simulations (e.g. LearnSmart™)?		module and LearnSmart™ labs
For these alternative laboratory simulations, how appropriate were these to your actual lecture material or laboratory practical sessions?	The lab safety simulation had somethings which were different to the workplace for example it didn't highlight that long hair should be tied back. There were also American terms used which differed from UK terminology	These were also highly appropriate.
Would you use these if they were for summative assessment (they are summative in Biomedical Science and Cell Biology)	90% of interviewees thought there should be for formative assessment	LearnSmart™ was used in Biomedical Science and Cell Biology modules. Students found LearnSmart™ labs worked with less technical glitches and were available as shorter individual sessions.
Do you have any other comments about virtual laboratory simulations and their use?	The LearnSmart™ simulations formed a portfolio and students liked these and could look at the practical skills ahead of the tutorial sessions. The setup of LearnSmart™ allowed students to pace themselves more easily with their work placement. The smaller and shorter segments could be completed in the workplace.	Positive about all the virtual lbs they have used, they liked the fact that they can go back and repeat whenever they like. Ideally students would like each simulation to be around 30 minutes long.

	Some simulations took 1.5-2 hours these could have been broken into shorter sections.	
How do you feel about replacing actual laboratory sessions with virtual laboratory practicals?	No. A mixture of virtual simulations alongside practical techniques is needed, the physical use of equipment improves dexterity. These students used the virtual Labster™ simulation as a replacement to an enzyme kinetics practical.	Should not be a replacement for laboratory work, even for distance learners. Stated importance of viewing and using real equipment. They like the availability of the virtual labs and would like to continue with the mixture of virtual and physical attendance practicals.

Table 2: Responses of Part-time work-based students and distance learning students to the semi-structured interview questions in column 1. These interviews were carried out separately.

Applied Biomedical Science work-based students

The first discussion group was the part-time BSc Applied Biomedical Science students. These students had all completed the Labster™ simulation focussing on Health and Safety and had successfully used the simulations on tablets, laptops and desktop computers. Students reported that they liked that the LearnSmart™ simulations integrated into a portfolio with which it was possible to return to review aspects covered in the simulations. With the time pressures of being in the workplace and studying this cohort suggested that the Labster™ simulations were quite long and that shorter simulations lasting 5-10 minutes might be more compatible with working. When asked about the level it was suggest that both “resources more suitable for level 4 (first year) than 5 or 6”. Having had experience working in diagnostic laboratories these students highlighted that there were some differences in the simulations

compared to the actual lab work. In the UK the term “slope culture” is applied to microbiology where agar is set at an angle, these students flagged that the US terminology of “slant cultures” was used in the LearnSmart™ simulations which initially caused confusion. Although this cohort felt the simulations had given a rough idea of how to complete practical techniques, it was remarked that the simulations were “…better for theory than actual techniques”.

Students reported that there were some technical issues with setting up both types of simulations and when asked about whether they thought that these simulations should be used for formative or summative assessment 9 out of 10 students suggested that they were more appropriate for formative feedback “perhaps not summative due to some technical issues”.

Students were asked if the simulations should be used to replace practical classes, but the response was “Should not be used as a replacement for any practical work, even for distance learners it is important to view and use real equipment”. These students were very positive that their program enabled them to have mixture of virtual and attendance practicals. Students suggested that “ideally all sessions should be no longer than 30 minutes, to allow flexible completion, for instance in part of a lunchbreak.”

Distance Learning Work-based Students (Foundation Biomedical Science degree)

In the second discussion group the distance learning students were asked about their experiences of using the virtual laboratory simulations. These students physically attend the University in January and July for exams and in May for a four-day workshop, they were invited to this interview after an exam in January, which partially accounts for the low participatory rate (20%). The nature of the distance learning means that the students have less time at the University than work-based students studying part time. Students on the distance learning modules were impressed by content of both Labster™ and LearnSmart™ and commented that there was “good alignment with modules and workplace activities”. They used the Labster™ simulations to support other material provided in the module in order to reinforce learning. The students considered that the LearnSmart™ content was highly

appropriate, and that they “like the shorter sessions that are available”. One advantage which was highlighted by these students was that it was possible to return to the simulation and repeat it as many times as they liked.

In contrast to the BSc Applied Biomedical Science distance students the part-time work-based students were satisfied to replace a practical class with a Labster™ simulation. They felt that the simulations could have been used to introduce new techniques or pieces of equipment, such as spectrophotometers, rather than backgrounding the laboratory simulations with specific stories or scenarios. Students were asked for what purposes they used the virtual laboratory simulations and the reasons given included for supplementing the notes from the lectures, for revision purposes and in order to prepare for the practical classes.

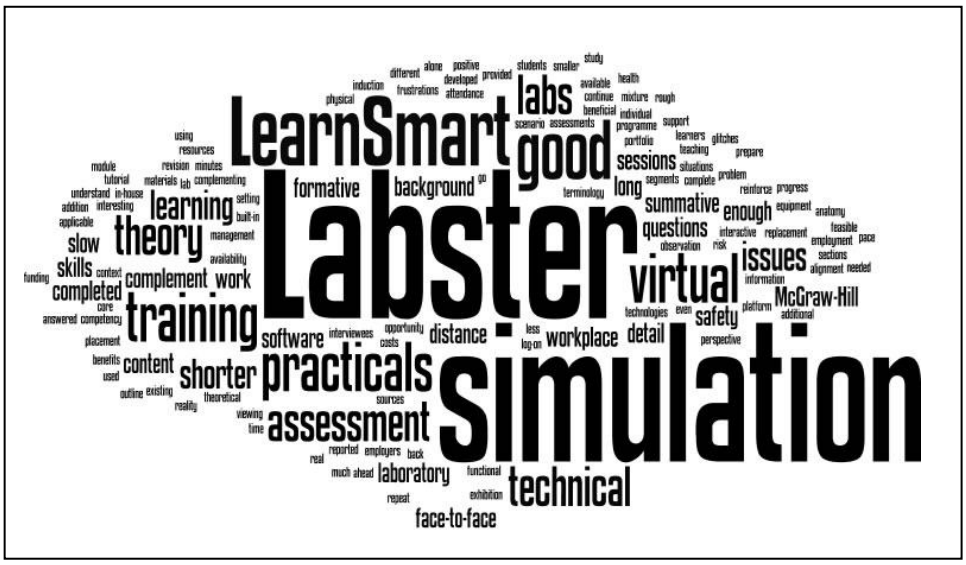

Figure 1: Summary of the key words emerging from the interviews:

Discussion

We report on a project which has brought employers, work-based students, and distance learning students' opinions together to evaluate virtual laboratory simulations commercially available from two manufacturers. The European BEEHiVES project has highlighted a need for a strategic partnership triangle between HE institutions, students and employers; and this report provides a model of good practice where employers are informed about advancements in teaching tools and have been given opportunities to discuss the limitations and potential of such advances alongside students who have experiences of these tools. Creating a dialogue with employers enables the development of a partnership and further development of positive comments to progress work-based learning, e-learning and training. There is scope for the development of bespoke resources and work-based training tools.

These are all students who are taking the work-based learning modules. This report has looked at these virtual simulations to determine their usefulness in the development of both work-based and university skills. There is an overlap in the development of work-based skills while gaining academic skills.

There are several advantages which have been identified in this study for the use of virtual simulations for work-based learning: these include the intercalation of theoretical knowledge within the simulation which is tested as the participant progresses. The simulations provide a platform which can be accessed at any time and in any place and do not need a specific trainer. An advantage of using virtual laboratory simulations for work-based learning include the reduced cost involved in training, travel to university, optimisation of time and reduced materials needed for laboratory work. However, there are costs associated with the licenses to access these simulations. Employers were supportive of the use of virtual laboratory simulations for scenarios faced by all biomedical scientists such as health and safety training; in order to prepare them for the workplace. However, employers thought that virtual simulations should be used to complement existing employer training rather than to replace this, with this in mind employers suggested that the virtual simulations could be used for risk assessment or specific scenarios. The use of virtual simulations for risk assessment has been previously described in engineering (Puschmann *et al.,* 2016) and simulations to mimic

specific scenarios are widely used in surgery (Hviding *et al.,* 2009) and medical education (Cannon-Bowers, 2016).

At present there was no support from employers to replace face-to-face competency testing with virtual simulations, although employers supported the virtual simulations as additional training tools. Labster™ virtual laboratory simulations have been used in medical education to prepare first year students using genetic counselling scenarios with students reporting that the simulations increased their confidence in future patient consultations (Makransky *et al.,* 2016) and there is an ongoing project to develop online simulations for the biotechnology industry, however data has not been published about whether this would be for training or the assessment of competencies.

There are significant costs for employers in providing work-based training which include time pressure required for training in addition to the costs of providing materials for students to practice on in the laboratories or the costs of taking scientific equipment "off-line" in diagnostic settings to enable training. There is surprisingly little published about the cost-benefit of adopting simulations outside of the military and there is debate about the parameters by which to effectively measure such cost-benefits (Fletcher & Wind, 2013).

The students interviewed here were at early stages of their careers and the interviews focussed on the accessibility of the virtual simulations, the suitability of the simulations for assessment purposes and the potential for replacing laboratory sessions with simulations. Both distance learning and part-time work-based students had used the simulations to enhance the information that they had gained from taught classes. Neither cohort was in favour of replacing practical classes within the university with the simulations. Time was important to these students and both cohorts indicated that simulations with shorter completion times would be particularly suitable and would enable further study in the workplace. Both cohorts identified that there had been technical issues with both types of simulation leading one student to propose that these would be unsuitable for summative assessment until technical issues ameliorated. Discussions with students did not expand to use in the workplace for competency testing.

Work based students report favourably about the use of virtual laboratory simulation to enhance theoretical concepts. However, the simulations would be most beneficial if they

could be completed in small segments which would align with the available study time in the workplace, for example during breaks.

A concern to employers was the cost of introducing virtual simulations in the workplace. The report recommends a cost benefit analysis to determine if the replacement of some face-to-face training by senior members with virtual simulations would offset the costs of the virtual laboratory software. An additional consideration would be the time required initially for work-based trainers to work with the providers of the virtual laboratory simulations to develop bespoke resources. With ongoing changes in technology and practices as determined by organisations and service accreditation bodies there would also be a requirement to audit the suitability of these resources from time to time and modify them to meet any changes to practice that have taken place.

The limitations of the study include the small group numbers for interviews and the researchers recognise that the invitations to attend the interviews inherently introduce bias, as this is likely to attract highly motivated and engaged individuals. The low participation of distance learning students is likely because of the limited amount of time that these students are physically present at the University.

Conclusions:

In summary the student experience was enhanced by provision of virtual resources and possible uses of virtual simulations were recognised to support training in the workplace. Students and employers agreed that simulations were suitable to prepare for and enable deeper understanding of practical work, not as a replacement for hands on activities. There were some technical issues with the virtual simulations which need to be resolved. Having used two different virtual simulations both groups of students suggested that learning packages should be brief to enable flexible completion time which would be more compatible with work-based learning. Finally, students suggested that the virtual simulations were good for formative assessment, but not for summative assessment; this sentiment was mirrored by employers who favoured the simulations to complement existing employer training but were not in favour of the simulations as potential replacements for competency testing.

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Figure Legend

Figure 1: Summary of the key words emerging from the interviews. Interview responses were typed up. Size of the word indicates frequency of usage in interview responses. Key terms were normalised to a standard form e.g. simulation, simulations and simulating became simulation. Common English language terms were removed. Figure created in Wordle (http://www.wordle.net/)