Parasitology eLab: a Covid-19 pandemic induced drive for change to facilitate laboratory teaching-learning practices for undergraduates

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Abstract
The Parasitology eLab is a novel virtual learning environment developed amid the COVID-19 pandemic. To evaluate the Parasitology eLab educational website, this study focused on assessing students' perceptions on the new learning environment and explored its impact on their academic achievements in laboratory assessments. This was an exploratory study that used a mixed method of data collection, including questionnaire surveys and assessments to evaluate learning achievement. Quantitative analyses were conducted to express descriptive statistics and correlations. The online survey received a good response. The students appreciated the creation of the website during the pandemic situation and expressed a high degree of satisfaction with its content and utility. This paper presents findings on students' perceptions on the design of the website, its functionality as a learning resource in parasitology, and its positive impact on academic achievements of students in laboratory assessments.

Introduction

The COVID-19 pandemic posed challenges for The Open University of Sri Lanka (OUSL), even though e-learning platforms were available for teaching-learning from pre-COVID times. Because of restriction to face-to-face teaching, one main challenge faced by teaching staff of the Bachelor of Science degree programme of the Faculty of Natural Sciences (FNS) was the delivery of courses with compulsory laboratory-based components. In this scenario, teachers were compelled to creatively look at alternative tools for the digital transformation of laboratory classes and some academics in the FNS offered innovative online adaptations to sustain teaching-learning of practical courses, through online courses hosted in the Moodle Learning Management System of the university (Wijeneyaka & Iqbal, 2021; Jayatilleke et al., 2020).

Here we report a case study that integrated technology and innovation to develop an educational website named the Parasitology eLab. A few websites are available for Parasitology education to facilitate transfer of essential skills for the diagnosis of infections (Peña-Fernández et al., 2020; Linder et al. 2008). However, this is the first educational website designed and developed by the OUSL as a supplementary virtual resource, supporting teaching-learning of a specific course. Parasitology is offered as a Level five optional course in the in the BSc degree of the FNS. The course involves compulsory laboratory sessions conducted over several days, where leaners are provided instructions by staff before they engage in various exercises to acquire practical concepts and skills. Because hands-on exposure is essential to acquire certain skills for the diagnosis of parasites, this virtual resource did not replace such experimental work. Whilst providing knowledge on parasites and their infections, the website was expected to replace pre-lab demonstrations provided by staff on practical concepts underlying the laboratory exercises and to provide support for hands-on exposure in the laboratory setting when onsite teaching learning activities at the university were permitted under strict health regulations.

This paper presents the findings of an exploratory research study conducted to evaluate the Parasitology eLab educational website with actual learners. As opined by Wijeneyaka & Iqbal (2021), there could by many factors, including local factors specific to a cohort of students, that determine adoption of technological tools in education. Learners are more likely to embrace the technological transition if they perceive benefits in using the resource. In the diffusion of innovations theory, Roger (2003) identified perceived attributes of a new idea, practice, or object, including technological innovations, influence its adoption by users over time. Similarly, as per the Technology Acceptance Model, user perceptions are among the factors that determine acceptance of a technology (Davis et al. 1989). Thus, in evaluating the Parasitology eLab resource, we set out to gather students' perceptions on the website as an important first step. How students had experienced the Parasitology eLab was expected to inform what specific improvements might be required to make it more effective, and as well provide a measure of its acceptance and adoption, consequently serving to shed light on its potential utility as an effective virtual resource for parasitology education in the post-covid scenario.

Objectives

The purpose of this research was to:

- assess the perceptions of learners on the Parasitology eLab website, and,
- explore the relationship between the website access and academic achievement of students in the laboratory assessments

Methodology

Parasitology eLab

The website was developed on the WordPress content management system (www.wordpress.org) and was hosted within the university domain. The website was made available publicly at https://parasitology.ou.ac.lk/.

The Parasitology eLab composed the following virtual learning modules for the self-guided study of parasites and their diagnosis.

- Web microscope module: Provided a basic virtual microscope for the observation of parasite stages. To prepare images for a virtual platform, microscope slide sets of parasites used in the Laboratory class were photographed using a camera set up (C-PGS, Optika, Italy) attached to a light microscope (B-290, Optika, Italy). Students could interact with the virtual microscope to zoom images to see diagnostic features of parasites in greater detail.
- Virtual laboratory module: Provided videos prepared by staff to demonstrate several basic techniques used in the laboratory diagnosis of parasites in coprological and blood specimens. This module was designed to help learners to independently perform parasitological examinations in the laboratory for the microscopic detection and identification of parasite stages and species.
- Parasites A-Z module: Linked the students to the DPDx website of the Division of Parasitic Diseases and Malaria of the Centers for Disease Control and Prevention (CDC), USA. This is an open educational resource available in the public domain that offers information on parasitic infections.
- Virtual activities module: Provided three activities to facilitate self-assessment and evaluation of knowledge gained by studying the virtual learning modules.

Students were informed of this new virtual resource via the online course about five months before the laboratory sessions and of the requirement to study the Parasitology eLab content before attending the onsite laboratory sessions, which were conducted when the authorities permitted restricted face-to-face academic activities at the university.

Assessment of students' academic achievement

A pre-test, in the form of 10 quizzes (10 marks), was conducted at the beginning of the onsite laboratory session to examine preparation for the laboratory class. Then at the end of the onsite session, the students were assessed through an online test of 20 questions, where problem-solving skills in identification of parasites and parasite infections were tested (20 marks). As well, a case study was provided where students had to report findings on given stools and blood specimens, after individually performing relevant techniques used in the laboratory diagnosis of parasite infections. Marks of both these assessments contributed to the final practical assessment mark (30 marks).

Data collection and analysis

This was an exploratory study that used a mixed method of data collection. The study participants were the students enrolled in the Parasitology course in the BSc degree programme of the OUSL offered during the academic year 2020/2021.

A quantitative methodology was used to study the perceptions of students and their interaction with the Parasitology eLab website using questionnaire surveys. First, when students attended the onsite practical session, a brief questionnaire collected information on the frequency of interaction with the website modules. Secondly, an online survey was used to study the perceptions of students. This online questionnaire contained both closed and open-ended questions regarding the structure and format of website, learning utility and improvements required. Students were asked to respond to the online survey after they had participated in the onsite laboratory sessions.

To assess the relationship between the website access and performance in laboratory work, pre-test marks and practical assessment marks were collected from academic records of students.

For quantitative data analysis, descriptive statistics, a one-way ANOVA test, a Kruskal-Wallis test and a Pearson correlation coefficient were used. The Open-ended questions were analysed using content analysis. All the quantitative analyses were conducted using Microsoft Excel and the Minitab statistical package. The statistical significance level was set at $p < 0.05$.

Findings

Demographics of survey participants

A total of 114 participated in the onsite laboratory sessions, of which 91 (80%) had voluntarily responded to the online survey. As shown in Table 1, the majority were female (91%), single (53%), employed (cumulative % of fulltime/part time/self-employed = 60%), between 25-29 years (56%) and were enrolled in the Colombo (CRC) or Kandy (KRC) Regional centres (88%).

Table 1: Demographics of the online survey participants

Gender	Female	Male				
	91%	09%				
Age	<24	25-29	30-34	35-39	45-49	>50
	10%	56%	26%	03%	03%	01%
Civil Status	Single	Married				
	53%	47%				
Employment	Full-time	Part-time	Self-employed	Not employed		
	42%	05%	13%	40%		
Centre	Colombo	Kandy	Matara	Jaffna		
	44%	44%	11%	01%		

Parasitology eLab access

A significant proportion of students (> 90%) had accessed the web microscope and virtual laboratory modules, the majority (59%, 64%, respectively) interacting with them a few times (Table 2). In comparison to other modules, the virtual activities module was the least accessed (62%), where an average of 39% had never attempted the activities provided.

Table 2: Interaction with Parasitology eLab modules

Module	Responses - online survey (n=91)	Responses - onsite lab session survey (n=110)		
	Accessed	**Several times**	**Few times**	**Not at all**
Web microscope	92%	39%	59%	02%
Virtual Laboratory	91%	32%	64%	04%
Parasites A-Z	77%	15%	74%	11%
Activity 1	62%	17%	56%	28%
Activity 2		15%	47%	39%
Activity 3		10%	39%	51%

Assessment of the design of the website

Almost all students have found the overall layout and visual appearance suitable and engaging (95.6% strongly agree/agree), and that the design of the individual modules was appropriate for learning (Fig. 1). Students were highly satisfied with the website, with respect to its navigation (96.7%), how the information was organised (97.8%), as well its interactivity (93.4%). The following are a few quotations that reflect students' perceptions regarding the design of the Parasitology eLab and its accessibility.

> *"The website was easily accessible and it was easier to study the different stages of the parasite without having to go through each of them online"*
>
> *"Easy to access. informations are very clear. Easy to learn"*
>
> *"As we can magnify and observe the parasitic stages, it was really interesting and it increased our memorizing capabilities"*

No student disagreed on the suitability of the content and layout of the individual modules. For the navigation and organisation of information aspects of the website, a minority (<2%) had responded they "disagree" with the statement, The student who disagreed that information was organised well, also disagreed that navigation through the website was easy and had also requested to educate them about the website well in advance in the open-ended questions. All were made aware of the virtual resource well before laboratory sessions, but appears the student was ignorant of its availability until the day before the onsite laboratory session and as a result may not have had adequate time to go through the resource.

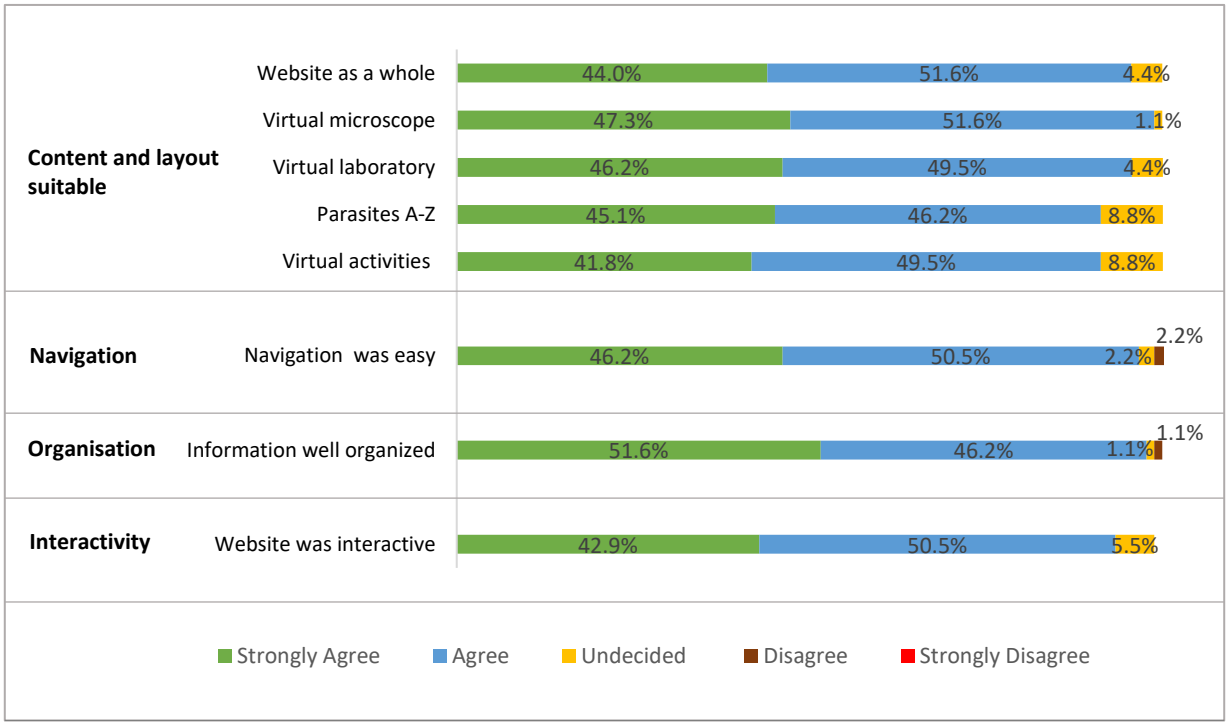

Figure 1: Level of satisfaction on structure and format of Parasitology eLab website

Assessment of the utility of website as a learning resource

A vast majority (96%) had used the virtual resource to prepare for the laboratory session (Table 3). Only five students had not perceived a beneficial effect on using the website to enhance theoretical knowledge (1%), for self-assessment (3%) or to learn about specific parasitic diseases (1%). Students indicated the specific modules of the website enhanced their ability to identify parasites (86%), to perform techniques in the lab session (92%), helped to improve theoretical knowledge (89%), and for self-assessment (75%). The significant majority (93%) had felt the content of modules was suitable to learn about specific parasitic infections and was relevant for their overall learning (98%). Overall, it is evident that the website had helped to enhance learning (98%) and students were highly satisfied (95%) with whole Parasitology eLab website. These perceived impacts were supported by the comments shared in the open-ended questions.

> *"Web microscope and Virtual Library are very helpful for my laboratory practical session"*
>
> *"got lots of information about parasite, their life cycles and diseases.as well as observe microscope views in different level it is very useful. and also videos give lots of knowledge about practical. I thik [sic] I got lots of knowledge. and it is very interesting"*
>
> *"As in such pandemic and for full time employees especially health personals, all the sections in the web resource was very much useful"*
>
> *"It was very easy to self study and see again and again if we did not get the idea"*
>
> *'Improved self learning'*

Previous research reported by Peña-Fernández et al. (2020) has also revealed the positive impact of a web-based learning package on a cohort of pharmacy students who valued it as an effective learning tool, that helped them to acquire appropriate knowledge and basic diagnostic skills in parasitology.

Table 3: Perceived benefits of using the Parasitology eLab website for learning

Item	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Used Parasitology eLab to prepare for laboratory session	49,5%	46.2%	4.4%	0%	0%
Web microscope module enhanced ability to identify parasite stages during lab session	42.9%	42.9%	14.3%	0%	0%
Virtual laboratory facilitated to perform techniques during lab session	44%	48.4%	7.7%	0%	0%
Parasites A-Z module helped to enhance theoretical knowledge	36.3%	52.7%	9.9%	1.1%	0%
Virtual activities for self-assessment	29.7%	45.1%	21.9%	2.2%	1.1%
Content was appropriate to learn about specific parasitic diseases	37.4%	56%	5.5%	1.1%	0%
Content of modules was relevant to overall learning	41.8%	56%	2.2%	0%	0%
Overall, website helped to enhance learning	45.1%	52.7%	2.2%	0%	0%
Overall, satisfied with whole website resource	41.8%	52.7%	5.5%	0%	0%

Narrative accounts of students highlighted a variety of styles and habits adopted by them to learn from the website. The following are some of the quotations that reveal how they had used the website for learning.

> *"it's like a short note to understand easily"*
>
> *"During travelling and free time follow the contents little by little"*
>
> *"I was [sic] refer eParasitology for so so many times. try to remember the information also images . But i did not study them starting from A end with Z. I refer them according to the order in the book. That make me easy to remember"*
>
> *"I watched all the pictures and videos. then i make a little note about all the parasites we need to study. it was very easy and interesting"*
>
> *"After learning the contents of Web microscope, parasites A-Z and virtual laboratory, I attempted the virtual activities"*
>
> *"It was easy to visualize the features of the parasite with the notes, and it helped me recognize the parasites without too much jargon"*
>
> *"printout the photos and information of parasites of e parasitology website and studied them and did all the virtual activities"*
>
> *"I followed them parallelly with the text book"*

The above shows the importance of considering a variety of learning strategies in the design of a website as the individual styles of learning are different. The design considerations should aim at making e-learning environment interactive and engaging with active collaborations and student learning involvement, using an increased choice of media to suit leaner preferences (Lee et al. 2004). Literature also reveals the blended learning approach is more suitable for laboratory-based training, where virtual tools are combined with traditional laboratories (Hamed & Aljanazrah, 2020). Our approach adopted a blended mode, where the Parasitology eLab modules served to replace visual and verbal presentations by the instructor before the practical session and students were required to participate in laboratory work physically to acquire the necessary skills in parasitology.

Correlation between website access and academic achievement in laboratory assessments

To examine whether there was a relationship between website usage and academic achievement of students, frequency of access was correlated with students' marks in the pre-test and practical assessments. Results showed

that there was a significant correlation ($p<0.05$) between performance in practical assessments and access of all website modules, except the web microscope (Table 4). Though the correction was low, the marks of students who had interacted with these Parasitology eLab modules several times had performed better in the pre-test and/or the practical assessments.

Table 4: Relationship between frequency of Parasitology eLab access and laboratory assessments

Interaction		Not at all	Few times	Several times
Web microscope	Pre-test	4.000±0.000	6.125±1.856	6.535±2.282
	PAM	13.875±0.530	14.484±4.091	16.599±4.937
Virtual lab	Pre-test	5.250±1.893	6.159±1.997	6.528±2.145
	PAM	16.188±3.636	14.493±4.265	16.771±4.767*
Parasites A-Z	Pre-test	6.538±1.984	5.975±1.954	7.500±2.129*
	PAM	16.740±4.744	14.578±4.334	17.602±4.615*
Activity 1	Pre-test	5.433±1.813	6.393±2.060	7.111±1.967*
	PAM	12.979±3.018	16.102±4.668	16.493±4.848*
Activity 2	Pre-test	5.571±1.850	6.451±2.072	7.375±1.893*
	PAM	13.375±3.432	16.360±4.712	17.023±4.788*
Activity 3	Pre-test	5.839±1.998	6.476±2.027	7.455±1.864*
	PAM	14.353±4.109	16.122±4.479	17.057±5.780*

*$p<0.05$ significantly different PAM: practical assessment mark

Literature reports of studies that showed virtual labs as effective as traditional labs, whilst others support virtual experiments improved students' achievements (Alneyadi, 2019; Darrah et al., 2014). Our results showed that using the Parasitology eLab had an impact on the students' level of academic achievement in onsite laboratory assessments. This implies students could acquire the required conceptual knowledge with the Parasitology eLab in preparation for the laboratory session, supporting previous research that report virtual instruction as an acceptable alternative to face-to-face traditional instruction by the instructor before the laboratory work (Hamed & Aljanazrah, 2020).

Overall perceptions and improvements suggested

The overall comments supported the view that students appreciated the novel learning resource and valued the effort and its usefulness. The following narratives support this view.

> *"It perfectly was helpful and am planning on using some details in it to study for my finals too. Overall, parasitology is the most effective, the most active course in learnousl i engaged in my entire degree…".*
>
> *"This is a wonderful step forwards for making parasitology interesting and lots less tough when studying"*
>
> *"Better new world experience for students, In subject level as well as in technology level"*
>
> *"Actually as in such pandemic and for full time employees this type of learning resources are very useful. please keep going"*
>
> *"it was an excellent work even during this pandemic situation .Thanks a lot for your enormous dedication"*
>
> *"Its very useful, and thank you so much, This is the only subject give us knowledge like this"*

Students also suggested a few improvements to enhance their experience with the website. Some of the specific suggestions are represented in the following quotations.

"Upload more videos on disease diagnosis"

"When viewing pics difficult to zoom... if its easy it will be more useful"

"It will be helpful and easy to learn if all parasites and stages belong to each order are define orderly and not in A-Z vise (name vise)"

"Explanation with audio showing parasite with explanation"

"more virtual activities"

"Providing quizzes and grades for their performance which would motivate the students to attempt all the resources in the website"

The overall findings of the study conducted to evaluate the novel Parsitology eLab resource, permit us to presume its potential use as an effective virtual resource for parasitology education in the post-covid scenario, with improvements to combine both synchronous and asynchronous components into the package.

Conclusions

This study portrays how the pandemic-induced drive compelled a shift towards virtual resources facilitating self-guided asynchronous learning in laboratory work of an undergraduate Parasitology course. The Parasitology eLab educational website aided to overcome academic disruptions and ensured recommencement of limited face-to-face activities permitted by health regulations; consequently, providing the practical experience essential to achieve the learning outcomes of the course.

The Parasitology eLab has introduced an effective virtual resource for parasitology education to complement traditional laboratory work. The students indicated strong support for using the website in learning parasitology and the novelty factor of this new virtual environment appeared to raise the students' enthusiasm and satisfaction. The acceptance of such technology enabled virtual tools by staff and students however will not only depend on the perceived benefits and pitfalls, but also on the institution's resources and policies that encourage adoption of novel teaching-leaching strategies.

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