Redes de Investigación e Innovación en Docencia Universitaria

Volumen 2022

Xarxes d'investigació i Innovació en Docència Universitària

Volum 2022

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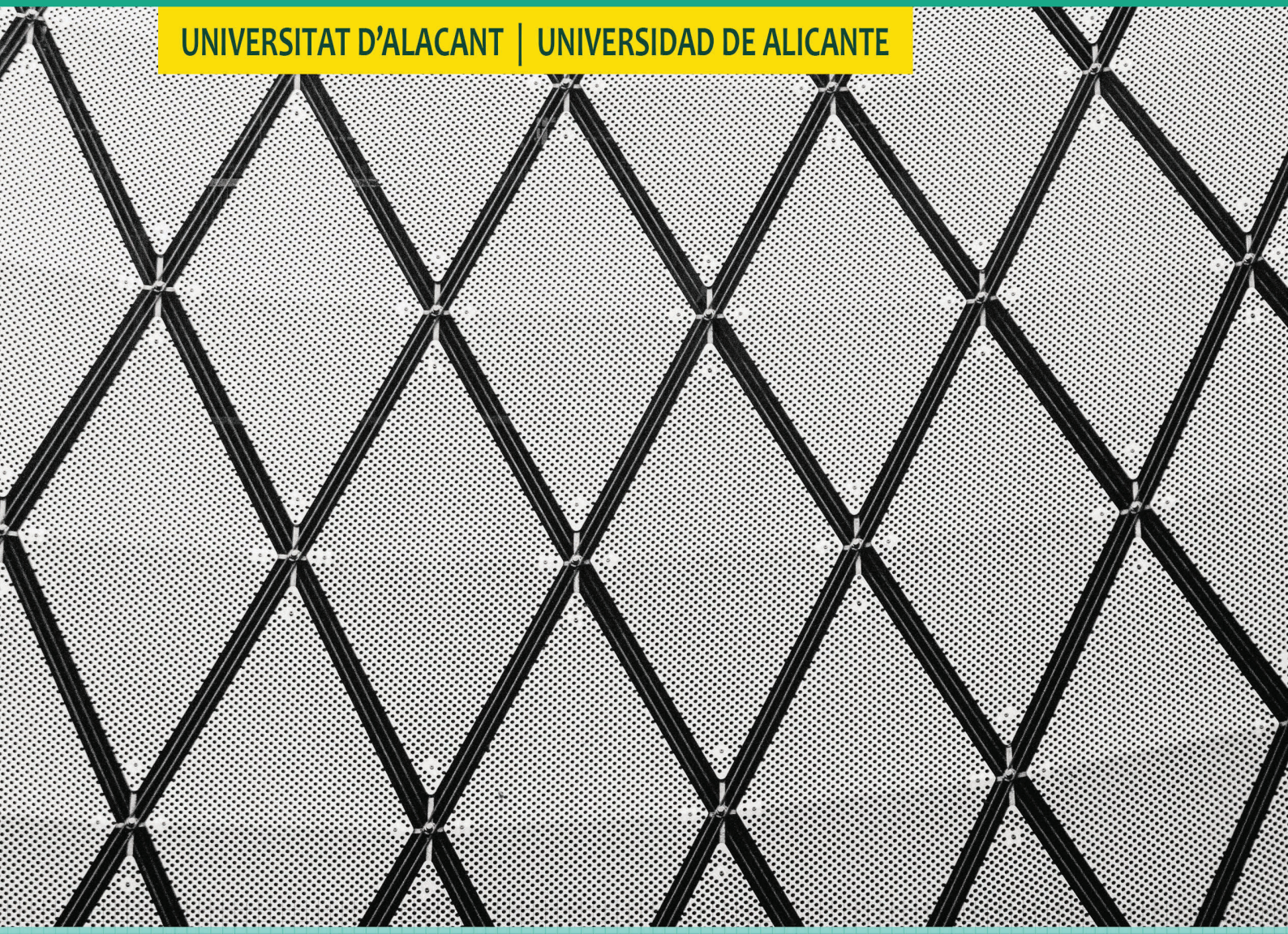

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Satorre Cuerda, Rosana (Coordinación)
Menargues Marcilla, María Asunción
Díez Ros, Rocío
Pellín Buades, Neus (Eds.)

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2022

Redes de Investigación e Innovación en Docencia Universitaria. Volumen 2022

Organització: Institut de Ciències de l'Educació de la Universitat d'Alacant/ *Organización: Instituto de Ciencias de la Educación de la Universidad de Alicante*

Edició / *Edición: Rosana Satorre Cuerda (Coord.), Asunción Menargues Marcilla, Rocío Díez Ros & Neus Pellín Buades(Eds.)*

Comité tècnic / *Comité técnico*:

Cristina Mansilla Martínez

Sergio Andrés Mijangos Sánchez

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Revisió i maquetació: ICE de la Universitat d'Alacant/ Revisión y maquetación: ICE de la Universidad de Alicante

Primera edició: / *Primera edición*:

ice@ua.es

ISBN: 978-84-09-39082-3

Producció: Institut de Ciències de l'Educació (ICE) de la Universitat d'Alacant / *Producción: Instituto de Ciencias de la Educación (ICE) de la Universidad de Alicante*

34. Clinical training to reduce infections of sexually transmitted parasites

Peña-Fernández, Antonio[1], Peña Fernández, M. Ángeles[2], Evans Dennis, Mark[1], Acosta, Lucrecia[3]

[1]*Leicester School of Allied Health Sciences, De Montfort University*

[2]*Universidad de Alcalá*

[3]*Universidad Miguel Hernández de Elche*

ABSTRACT

Infections due to intestinal protozoan parasites are increasing in Europe in men who have sex with men (MSM). However, sexual clinics do not routinely monitor for these sexually transmitted parasites (STPs). Our international team, led by De Montfort University (DMU, UK), has launched a complete open-access website package, named e-Parasitology© (http://parasitology.dmu.ac.uk/index.htm), which includes a battery of resources and tools (virtual microscope and laboratory) for the teaching and learning of the STPs of *Entamoeba histolytica*, *Giardia intestinalis*, *Cryptosporidium* spp. These virtual resources were tested with third year BSc Biomedical Science students at DMU in 2019/20 and 20/21, to evaluate their effectiveness, specifically on the acquisition of diagnostic skills. Students completed a focused 2-hour workshop using a clinical case study of *E. histolytica* affecting an MSM patient, and checked different virtual clinical slides available that presented structures of this parasite using the resources available in e-Parasitology. Thirty-seven and ten students voluntarily provided feedback at the end of the workshop, respectively. Most responders highlighted that e-Parasitology© helped them to learn the clinical and pathological characteristics of *Entamoeba* spp. (90% in 20/21), as well as how to diagnose infections due to *E. histolytica* (77.8%; 11.1% disagreed; 20/21 cohort). Our preliminary results suggest that e-Parasitology© facilitates the learning of laborious laboratory techniques for the diagnosis of *E. histolytica* and opportunistic parasites.

KEYWORDS: e-Parasitology©, sexually transmitted parasites, MSM, *E. histolytica*, diagnostic skills.

1. INTRODUCTION

Intestinal protozoan parasites previously considered as tropical infections are emerging as concerning pathogens in developing countries because of their increasing prevalence in men who have sex with men (MSM) (McNeil et al., 2022; Yanagawa et al., 2022). Transmission in MSM could occur during oral-anal contact, either directly or indirectly via sex toys or fellatio (Abdolrasouli et al., 2009; Escolà-Vergé et al., 2017). Moreover, increased use of risky practices such as chemsex (use of drugs immediately before or during sex), group sex, fisting and scat play (Mitchell and Hughes, 2018), in conjunction with the introduction of pre-exposure prophylaxis (PrEP) as an HIV-prevention strategy, would likely have been translated in an increased risk compensation (more risky sexual practices in conjunction with decline in condom use) (Jansen et al., 2020; Azarnoosh et al., 2021) and could explain the increasing prevalence of *Entamoeba histolytica*, *Giardia intestinalis*, *Cryptosporidium* spp. recorded in developed countries (Fernández-Huerta et al., 2019; Farraj et al., 2022). However, more epidemiological studies are needed as risk compensation has not been observed in all studies/countries, such as in the recent epidemiological study carried out by Streeck et al. (2002) in the German MSM population.

As timely diagnosis is pivotal for tackling infections and contributing to an overall decrease in sexually transmitted parasite (STP) incidence, the scientific community is recommending the introduction of rapid antigen detection tests for detecting these intestinal parasites during routine checks for sexually transmitted infections (STIs), especially among high risk groups (Fernández-Huerta et al., 2019).

To reduce transmission and morbidity of STPs, medical and other healthcare professionals should be fully aware of this infection route, as anorectal STPs can progress asymptomatically and/or require detailed knowledge to make diagnosis and undertake effective screening. Moreover, these professionals can be key to increase awareness and optimise management of these infections, especially in the MSM population. However, learning medical parasitology is complex because of the number of clinical competences that students need to acquire in a limited time, as well as skills to detect and distinguish a myriad of different microscopic parasite structures for their diagnosis (Linder et al., 2008). Moreover, learning this science requires overcoming important challenges, including a significant reduction in the amount of lecture/practical time dedicated to the teaching of parasitology, coupled with reduced access to appropriate resources and parasitology professionals worldwide (Dupouy-Camet et al., 2009). Furthermore, academics must have the necessary tools and resources to be able to incorporate recent technical advances and cutting-edge topics into parasitology curricula.

1.1. e-Parasitology© website: STPs' resources

To overcome the different challenges that medical parasitology education is facing, De Montfort University (DMU, Leicester, UK) started the development of e-Parasitology© (publicly available here: http://parasitology.dmu.ac.uk/) in 2015, in collaboration with practising National Health Ser-

vice Biomedical Scientists and parasitologists from the Spanish Universities of San Pablo CEU and Miguel Hernández de Elche (UMH). This web-based package, launched in 2017, has four modules to aid with the teaching/learning of medical parasitology (Peña-Fernández et al., 2020a): a) theoretical module, which contains engaging e-learning resources, formative quizzes and mini-games for promoting self-learning on the topic of common and emerging human parasites; b) virtual laboratory, with innovative resources for learning biomedical laboratory techniques for parasitology research; c) virtual microscope containing a library of real specimens, viewable across a range of magnifications, for parasitology diagnosis; d) virtual clinical case studies, for promoting acquisition of problem-solving, critical thinking and reflection skills to facilitate the acquisition of key parasitological diagnostic skills. The four modules were co-designed with multimedia developers (staff and students) and graphic design students, who were hired as paid employees from a range of different internal funding schemes to enhance student employability, following previously established principles of curriculum design for parasitology training, adult and behavioural theory (Sisson et al., 2010) and gamification pedagogies, to simplify the communication of complex scientific concepts following Universal Design for Learning approaches (Capp, 2017).

Since the package was launched, different resources have been built and added to strengthen the clinical training for the diagnoses, prevention and management of emerging STPs, specifically of *E. histolytica*, *G. intestinalis*, *Cryptosporidium* spp. For example, a virtual clinical parasitology study was introduced for a case of *E. histolytica* affecting an MSM patient, as it has been recently reported as the most prevalent STP in MSM who attended STI units in Barcelona with enteritis and proctocolitis (Fernández-Huerta et al., 2019). This virtual patient was co-infected with HIV, and lately is affected by opportunistic parasites because his immune system is compromised, specifically with *Acanthamoeba* spp., a free-living amoeba. Thus, this complex virtual case study includes a series of different virtual clinical slides of different amoebas, which might enhance familiarisation of the user to the different morphologies, organs, life cycle stages and features of these pathogens

In addition, relevant practical resources have been incorporated into e-Parasitology for the culture of STPs in a parasitology laboratory, a pivotal specialised technique for diagnosis and patient care, performing parasitology and epidemiological research studies, also demonstrating the characteristics of these pathogens. Thus, a highly interactive unit for the culture of *Trichomonas vaginalis*, a non-intestinal STP that affect the female lower genital tract and the male urethra and prostate, was created in 2020, as recent reports have highlighted the importance of including *T. vaginalis* testing in routine gynaecological examinations as its prevalence is increasing in Madrid (Bolumburu et al., 2020). Although *T. vaginalis* is rare in MSM in recent European epidemiological studies (Jansen et al., 2020), rectal testing has been recommended to be carried out in MSM living in locations where *T. vaginalis* is endemic, with high levels of genital infection (Hoffman et al., 2018). Information about this practical unit, which is populated with formative mini-games and activities to provide a holistic learning experience, can be found in Peña-Fernández et al. (2020b).

1.2. Aims

The objectives of this work were to test the effectiveness of these new virtual resources in enhancing the awareness of STPs, and specifically for the learning of clinical diagnoses and detection skills (microscopic and molecular) for *E. histolytica*, pivotal to tackle the increasing prevalence of these pathogens in MSM in Western countries in which *E. histolytica* is no longer endemic.

2. METHODS

2.1. Context and participants

The teaching intervention and testing of these resources was done with third year BSc Biomedical Science (BMS) students enrolled in the final year module of Medical Microbiology at DMU, in the academic years 2019/20 and 2020/21. The structure of the BMS programme can be found on the DMU website here: https://www.dmu.ac.uk/study/courses/undergraduate-courses/biomedical-science-bsc-hons-degree/biomedical-science-bsc-hons.aspx [accessed 31/05/22]. This cohort was specifically selected as they had previously completed a compulsory module on basic microbiology (level 4) and biomedical techniques (level 5), so they could provide an informed opinion on the utility and effectiveness of the specific STP virtual resources. Two cohorts are described and compared here to strengthen the robustness of our study.

2.2. Instruments

Quantitative and qualitative methods were used to evaluate the success of these resources in facilitating students' acquisition of the skills mentioned above and enhance awareness of STPs. We used the scaffolding of the validated feedback-questionnaire that was used to evaluate the e-Parasitology package (Peña-Fernández et al., 2020a), which was populated with specific Likert scale questions to assess the aims of our study in collaboration with participating universities. Electronic written approval from participants was recorded within the questionnaires, which were completely anonymous and distributed using Jisc Online Surveys (onlinesurveys.ac.uk). The questionnaire distributed in the most recent cohort of 2020/21 was also slightly updated to specifically record students' feedback on each group of parasites. Ethical approval was provided by the Research Ethics Committee at DMU (Ref. 1851; amendment approved 8th October 2019).

As qualitative methods, students' performance during the workshop (completion of clinical parasitology case study), was recorded. The level of ease with which they identified *E. histolytica*, and the awareness, interaction and engagement in the different activities organised throughout the course to enhance identification of other STPs and free-living amoebas (students were displayed with photomicrographs and mini-case studies within their lectures), were also recorded in conjunction with their results during the specific STP virtual case study. Students also previously completed a focused workshop on opportunistic parasites in their first year of studies, so speediness in tailor-

ing prevention techniques for STPs and emerging opportunistic parasites (*i.e. Entamoeba* spp. and free-living amoebas) was expected.

2.3. Process

We have followed previous successful methods. Briefly, students completed a focused 2-hour workshop using a clinical case study on *E. histolytica* affecting an MSM patient. Students needed to distinguish *E. histolytica* in different virtual slides that presented morphologies/life cycle stages of this parasite (trophozoites and cysts) and other opportunistic parasites, using the resources available in e-Parasitology© (specifically the virtual microscope, library and the theoretical section) to resolve the clinical case scenario proposed. The workshop was timetabled in small groups in a computer room and students worked in pairs to encourage team work. Results were discussed with the students even though they were prompted with instant feedback when completing the virtual case study, in order to clarify erroneous knowledge or misinformation and identifying potential issues/challenges found by students during their completion to enhance the case study. Additionally, e-Parasitology© was used to enhance the lectures and teaching delivered in this module so students received a holistic experience of the novel website before testing the package in this session.

3. RESULTS

Thirty-seven and ten students, academic years 2019/20 and 2020/21 respectively, voluntarily provided feedback. Table 1 describes the responses collected for each cohort. Results collected in both cohorts would suggest that students found the parasitology section in the Medical Microbiology module easier when using e-Parasitology©. Thus, although students found the parasitology section of the module difficult (48.6% and 30%; 19/20 and 20/21, respectively), a higher proportion found the module more challenging overall (62.2% and 50%), which might be attributed to the availability of the e-Parasitology© website since the beginning of the course facilitating early engagement on the parasitology content, although more studies would be needed.

Table 1. Students population and number of responses according to cohort of studies and sex.

Cohort	Total (registered)	Female	Male	N/A
2019/20	37 (149)	29	8	/
2020/21	10 (170)	7	3	/

N/A = not answered

Overall, responders valued the e-Parasitology© website as an appropriate resource to learn both groups of pathogens (*Entamoeba* spp. and free-living amoebas), specifically 91.4% and 80% for each cohort, respectively (Table 2). Moreover, most responders reported that the package aided their learning of diagnostic skills, specifically 77.8% for *E. histolytica* (77.8%, 11.1% disagreed vs. 70%, 10% disagreed; 20/21 cohort; Table 2). Similarly, most responders in the 2020/21 cohort indicated

that they learnt to characterise *Entamoeba* species (only 10% disagreed), which would be pivotal for the appropriate prevention of amebiasis (caused by *E. histolytica*; the second most common cause of parasitic mortality worldwide; Yanagawa et al., 2022). Moreover, 94% (5.6% neither agreed nor disagreed) and 90% (10% neither agreed nor disagreed) indicated that e-Parasitology© helped them to learn the clinical and pathological features of free-living amoebas and *E. histolytica*, respectively for each cohort (Table 2).

Table 2. Responses (%) to the feedback-questionnaire to assess the e-Parasitology© website as a learning resource. Colours indicate specific feedback on group of parasites (green=free-living amoebas; blue=*E. histolytica*)

		Strongly disagree	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
Completing the amoebas virtual case study increased my knowledge of these parasites	19/20	0	2.7	13.5	56.8	27
	20/21	0	0	20	40	40
The website has helped me to learn some clinical and pathological features of free-living amoebas and *Entamoeba histolytica*….	19/20	0	0	5.6	69.4	25
	20/21	0	0	10	60	30
	20/21	0	0	10	50	40
…. and has helped me to learn how to diagnose human infections due to free-living amoebas and *Entamoeba*	19/20	0	2.9	11.4	62.9	22.9
	20/21	10	0	20	40	30
	20/21	11.1	0	11.1	55.6	22.2
eParasitology has helped me to learn how to detect free-living amoebas to species level	19/20	0	0	13.9	58.3	27.8
	20/21	0	0	30	50	20
…. and how to characterise *Entamoeba* species.	20/21	0	10	30	40	20
I have learnt treatment strategies against these pathogenic amoebas….	19/20	0	0	11.1	58.3	30.6
	20/21	0	10	10	70	10
	20/21	10	10	0	70	10
…. as well as prevention strategies	19/20	0	0	11.1	58.3	30.6
	20/21	0	0	30	60	10
	20/21	0	20	0	60	20
Overall, the e-Parasitology package helped me with the study of these parasites	19/20	0	0	8.6	37.1	54.3
	20/21	0	20	0	60	20
e-Parasitology can support lecturers	19/20	0	0	0	50	50
	20/21	11.1	0	0	44.4	44.4

The materials used to build the novel laboratory resource for the culture and management of *T. vaginalis* were initially tested using a blended approach with final year BMS and BMedSci Medical Science students at DMU in April 2019, who completed a voluntary internship for learning cell and parasite culture following the visit of an USP-CEU academic through an Erasmus+ mobility grant. Twenty-two students attended these sessions; 9 (8 BMS, 1 BMedSci) provided comprehensive feedback (*data not published, briefly described here for informative purposes of the effectiveness of the STP virtual laboratory resources created*). Prior to attending the laboratory session, participants were asked to check the e-Parasitology© cell and parasite culture units, and had an overview of the *T. vaginalis*'s resources. 88.9% reported that the e-learning units (22.2% agreed, 66.7% strongly agreed) facilitated their learning; one student (11%) indicated that the units were difficult to understand. A similar percentage indicated that the videos of a technician performing the different steps to culture *T. vaginalis* enhanced their learning. Most students (55.6% agreed, 33.3% strongly agreed) indicated that they learnt basic skills to perform cell/parasite culture.

4. DISCUSSION AND CONCLUSIONS

Recent modifications and updates to introduce dedicated resources and tools for the study of STPs in the e-Parasitology© package are shown to be appropriate and effective, as a higher proportion of our students indicated that they learnt to diagnose, treat and prevent infections due to *E. histolytica*. Similar results were observed regarding free-living amoebas, for both cohorts of students. The slightly lower percentages recorded in the 2020/21 cohort might be attributed to the fact that all the module was delivered virtually in the Blackboard© virtual learning environment due to the COVID-19 pandemic, which could also explain the lower number of responses collected. Diagnoses, treatment and prevention are competences of public health importance to manage the infections and reduce morbidity and mortality produced by these parasites.

Moreover, providing early diagnoses and appropriate treatment will also help to reduce drug resistance, an increasing and concerning health threat (Pedra-Rezende et al., 2022; Picot et al., 2022). Our results support those found in fourth year MPharm Pharmacy students enrolled in the Clinical Analysis & Diagnostics II module (UMH, Spain) in 2020/21 (n=74/125), following similar methods. Specifically, 73% (1.4% strongly disagreed; 4.1% disagreed) indicated that they learnt how to diagnose infections with these parasites (Peña-Fernández et al., 2022).

The effectiveness of the virtual microscope slides created to learn to diagnose and identify these parasites could be attributed to the fact that e-Parasitology© provides students with the opportunity for self-learning and access to the content outside teaching hours to strengthen their diagnostic and clinical skills (Strube et al., 2018). Moreover, previous studies have reported a significant increase in performance of students that have used a virtual microscope *versus* a light microscope (Hamilton et al., 2012). Similarly, the mini-videos available of a technician describing all the different steps for coprological analysis, staining and parasite culture would facilitate students' learning and acquisi-

tion of these skills and align with those reported in similar experiences for the teaching of essential laboratory techniques (Miyamoto et al., 2019). Virtual laboratories have been highlighted as important resources to complement practice skills (Radhamani et al., 2021); we recommend the use of the e-Parasitology© virtual laboratory as a blended approach to improve students' learning and prepare them for in-person laboratory practicals.

In addition, responders identified the e-Parasitology© package as an appropriate virtual resource to strengthen traditional face-to-face lectures, which highlights the importance of multimedia and virtual resources in learning (Roberts, 2017). Rad et al. (2022) has recently found similar efficacies in the learning of medical techniques in students that used face-to-face *versus* virtual methods, which could explain our results. Thus, both cohorts indicated that the resources created helped them to study STPs (91.4% and 80%, respectively) could be also be attributed to the fact that students enjoyed using e-Parasitology© (91.7% and 88.9%, respectively). Enjoyment is pivotal in virtual resources and games to be effective (Pechenkina et al., 2017). The ease of use of the e-Parasitology© website would have also contributed to students' engagement and interaction (40% very easy; 30% easy; 30% neither easy nor difficult).

Future developments to enhance this STP training will include the development of resources for aiding students to differentiate *Entamoeba* species from non-pathogenic amoebas and *Dientamoeba fragilis* (as the trophozoites forms of this enteric flagellated parasite can be easily confused with *Entamoeba* spp.), as well as creating further laboratory resources to facilitate the learning of novel diagnostic and biomedical laboratory techniques, which will follow the scaffolding of the *T. vaginalis* culture e-learning unit.

In conclusion, our results, although preliminary owing to the low number of responses collected, particularly in the second cohort of students, they would suggest that e-Parasitology© facilitates the learning of lengthy/intensive laboratory techniques for the diagnosis of these STPs, specifically *E. histolytica*. e-Parasitology© could be used to enhance awareness of STPs among healthcare professionals such as general practitioners, and might be also be appropriate to increase awareness and minimise infections in individuals reporting sexually risky activities who attend STI units.

ACKNOWLEDGMENTS

This project has been funded by: The Teaching Innovation Project Fund at De Montfort University (scheme 2015-16), two DMU SAAS funded internal placements (2018/19 & 19/20) and three Graduate Champions positions (2020-21), all awarded to Dr. Peña-Fernández's team. The authors also acknowledge support from the Faculty of Health & Life Sciences and DMU for access to critical resources, including software licenses and computing facilities.

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