Biophotonics box: educational kit for multidisciplinary outreach activities in optics and photonics

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Abstract: The biophotonics box enables multidisciplinary/interdisciplinary and self-paced learning with at-home experiments using low-resource components. Experiments can increase the interest of students in STEM subjects by emphasizing the real-life applications in biology and medicine.

1. Introduction

Online teaching and learning (OTL) have rapidly grown over the years along with the number of universities offering online courses. After the COVID-19 pandemic, OTL has become widely adopted given the social distancing requirement and the school closures. One of the most affected aspects of OTL are laboratory classes, which are main components of the curricula of most physical, chemical and life science courses. Virtual labs have been developed before the pandemic to complement students learning typically when experiments would be unpractical with manual measurements or upon shortage of specific laboratory resources for activities with large groups of students. However, considering that hands-on experience is of paramount importance to enable students to place the lecture theory in an appropriate perspective, the use of virtual labs has raised many concerns among educators [1,2]. In addition, decreased student learning has been attributed to negative psychological effects of extended home isolation and, particularly in low-income homes, lack of access to high-speed internet and electronic devices needed for online learning [1]. Although a number of at-home experiments have been proposed in the past, but only a few of these experiments cover light concepts in low-resource settings [2]. To provide educators a way of bring creative at-home experiments to students, we have developed an educational kit (biophotonics box) which contains low-resource components and does not require access to a computer to run experiments. Our kit was designed to increase the interest of undergraduate students in pursuing a career in biophotonics or related area while offering the student the choice to either make quick experiments or explore different experimental conditions using the same kit components.

2. Material and methods

The biophotonics box is an educational kit developed to replace laboratory experiments of previous 7-hour in-person biophotonics workshops conducted during the Irish Photonic Integration Centre (IPIC) annual undergraduate and postgraduate summer student bursary program at Tyndall National Institute [3,4] combined with computer simulations [5]. Our educational kit consists of a set of electronic components for an ultraviolet, red, green, blue light emitting diode (UV-RGB LED) circuit, as well as materials to (1) demonstrate fluorescence in daily life objects, (2) to make phantoms mimicking biological media such as tissues, and (3) to make a smartphone microscope. Experiments designed within the kit demonstrated concepts used in biophotonics applications including light absorption, scattering, fluorescence excitation and emission, diffusion, and microscopy. The experiments can be adapted to other disciplines using the same concepts. Quick experiments can be reproduced for reinforcement of optics/photonics concepts and to share concepts learned with students' family and friends. A detailed guide of experiments of our educational kit can be found in [6].

Biophotonics-box experiments (BBE) were tested in combination with lecture-based learning (webinars) and computer simulations during our 2020 biophotonics workshop (part of the aforementioned summer student bursary program). Attendees involved Irish-based students (11 out of the 15 students registered for the bursary program). The workshop was conducted virtually and consisted of a total of five 1½ h long webinars with three of them featuring biophotonics concepts, applications and career aspects, one webinar on computer simulations in diffuse media, and one webinar discussing the key BBE followed by a quiz on biophotonics concepts covered during the workshop. The discussion on BBE was done in the last webinar. Students had approximately 1-2 weeks to perform BBE at home depending on when their biophotonics box was delivered to them. Students' feedback on the biophotonics box was collected in a form of multiple-choice questions (with option for comments) after finishing the workshop activities.

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3. Results

The students' feedback (Fig. 1) showed that 90.9% of respondents considered BBE important for their learning process, 88.9% covered >75% of the instructions of experimental manuals, 81.8% were "interested" or "very interested" in BBE and >88.9% considered the overall learning, quality of manual instructions, quality of subject matter "good" or "very good". Our results suggest BBE was well received in various aspects of teaching and learning.

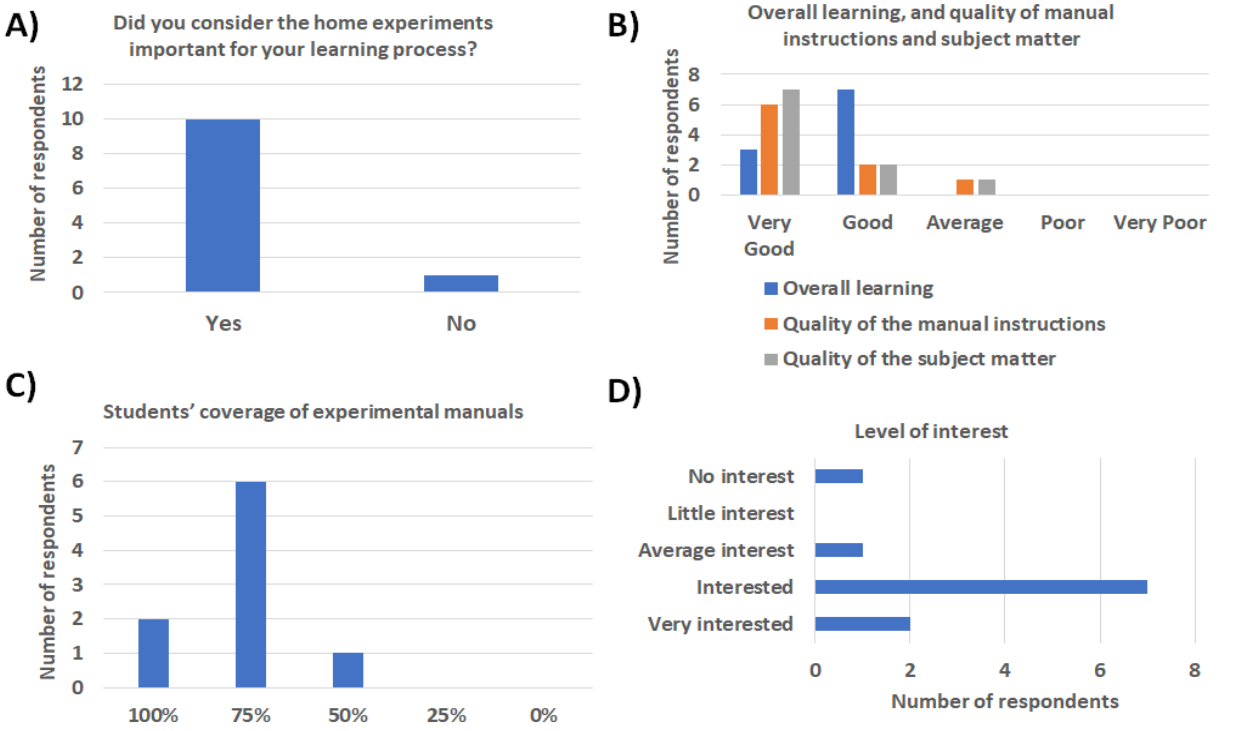

Fig 1: Students' feedback in terms of A) importance for their learning, B) overall learning, quality of manual instructions, quality of subject matter, C) students' coverage of experimental manuals and D) level of interest on biophotonics-box experiments.

4. Conclusions

The biophotonics box has been successfully tested in an outreach activity/small classroom setting and received positive student feedback. The biophotonics box offers an attractive option of fostering multidisciplinary/interdisciplinary teaching and learning while increasing the interest of students in Science, Technology, Engineering and Maths (STEM) subjects by emphasizing the real-life applications in biology and medicine.

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