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Abstract

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Disciplines

Engineering | Science and Technology Studies

Publication Details

Lee, W. C. C. & Alici, G. (2019). Smart approaches in facilitating engineering students to learn health technology. In R. J. Howlett & L. C. Jain (Eds.), *Smart Innovation, Systems and Technologies* (pp. 175-182). Germany: Springer.

Smart Approaches in Facilitating Engineering Students to Learn Health Technology

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Abstract. Partly due to the aging population around the world, job markets for developing biomedical devices and technology have been rapidly expanding. Organizations are recruiting engineers of various disciplines to design and test biomedical devices. This arouses interest of some engineering students to take academic subjects to learn some health technology, while keeping their main disciplines in specific engineering areas like mechanical engineering. Engineers need to have good understanding of the human body and different sorts of diseases, before they can apply good engineering solutions to solve the medical problems. However, teaching engineering students without prior education in medical-related aspects could be challenging. This paper presents the use of e-learning and some other interactive teaching approaches to facilitate master-degree engineering students to learn biomedical devices and technology. The factors which may assist in success in multi-disciplinary learning and the possibility of implementing the similar in undergraduate courses are discussed.

Keywords: Engineering, Health Technology, E-learning, multi-disciplinary

1 Background

The aging population around the world is leading to an unprecedented need for medical devices and technology [1]. Australian researchers have found medical-device industry to be among one of the fastest growth sector, and called for measures to ensure supply of appropriately skilled graduates [2]. Globally, the market for medical device technologies has reached US \$411.8 billion in 2013 and is expected to soar to over \$530 billion by 2018 [3].

Biomedical engineers are trained to work in the industry of medical devices and technology. However, there were reports commenting that lack of medical content in biomedical engineering training had made engineers suffer from the “easier said than done” work in medical fields [4]. Some medical-device companies are recruiting engineers from other disciplines to do the job. For example, mechanical engineers are recruited to mechanically design and test orthopaedic implants. These workers could experience difficulty in communicating the medical needs with clinicians and patients [5]. Academia should identify ways to improve medical content in engineering curriculums and increase the flexibility of engineering students to take medical-related subjects to enable engineering graduates to have an option to work in this fast growing industry.

While Biomedical Engineering courses offer both medical-related (e.g. anatomy, physiology and subjects covering different diseases) and engineering (e.g. electronic and mechanical engineering) subjects, their student intake numbers are usually much smaller than traditional engineering courses. Some universities are trying to offer subjects which provide multi-disciplinary education allowing future engineers to sit together with future clinicians to learn the ways to solve health-related topics [6]. Engineers need to have good understanding of the human body and different sorts of diseases, before they can apply good engineering solutions to solve the medical problems. The challenges for engineers to learn medicine and related technology have been great.

This paper presents the use of e-learning and some other interactive teaching approaches to facilitate engineering students to learn biomedical devices and technology. The factors which may assist in success in multi-disciplinary learning and the possibilities of implementing the similar in different levels of education are discussed.

2 The Students and the Subject

Twenty-seven master-degree students were enrolled in the subject Rehabilitation Engineering. The first degrees of the students were mechanical (33%), electronic (30%), electrical (26%), civil (7%) engineering and others (4%). They were enrolled as either full-time (67%) or part-time (33%) taught master degree programs.

The subject Rehabilitation Engineering, which lasted 13 weeks over one academic session, was designed for taught (coursework) master-degree students. The subject aimed to provide students with knowledge on common neuro-musculoskeletal disorders as well as to review and simulate thinking over the use of engineering solutions to those medical problems. It consisted of 33 hours (3 hours/ week) of combined lecture and tutorial as well 6 hours of laboratory sessions. All teaching sessions were conducted at nights to allow some full-time workers to join in the class.

3 Teaching Approaches

3.1 Smart Learning Through the Internet

Learning medical disorders online: Coping with the lack of in-depth knowledge in medicine of the students was one priority in this subject. While the students were provided with the names of common physical and sensory disorders as well as some general descriptions during the class, they were required to seek further information for the medical disorders. The students were requested to submit answers to some short questions in their assignments and quizzes, which tested their understanding of the medical terms.

Assessing credibility of the internet-based information: While the students relied on the internet for further reading on medical-related matters, discrepancies could exist among many different websites [7]. Students were reminded to assess the credibility of the materials they are reading. Factors important to credibility of online materials, which included author identification and qualification, presence of contact information, sponsorship by reputable organizations and citations to references [8], were discussed during the class. Feedbacks on assignments and quizzes also provided students with the sense of correctness and completeness of the medical information they have collected.

Encouraging deep learning: Students were also reminded to use higher-order thinking when reading the online materials. Such thinking involved evaluation and analysis of the information and creating new knowledge. In addition to assessing the credibility, students were advised to organize, test, compare/contrast different ideas and devise new thoughts. To facilitate students to employ higher-order thinking, there were involved in group projects (detailed in 3.4) requiring them to review and compare various approaches in applying technology to relieve a specific medical disorder and suggest ways of improvements. Feedbacks were provided to the students and students were required to refine their projects based on the suggestions.

3.2 Videos to Facilitate Understanding of Patients' Needs

Understanding the impairments caused by diseases or aging is very important before any engineering solutions can be devised. However, it is not easy to arrange transportation of different types of model patients with physical and sensory disabilities. Showing students videos could ease the problem. The teaching staff, with experience in real-life assessment of the disabilities, searched the internet and picked some appropriate videos to demonstrate to the students the effects of various diseases and degenerations on physical and sensory functions.

Two examples of using videos to teach medical problems are:

- 1) Spasticity – a condition which involves involuntary contraction of muscles causing joint stiffness that affects many people with stroke. Videos obtained

from Youtube™ were shown to the students allowing them to learn how spasticity affects stroke patients and overall walking experience.

- 2) Elderly gait – while textbooks show older adults have shorter stance time, step length and higher cadence compared to younger adults, students could have difficulty in grasping the characteristics of elderly gait. Students were shown some videos obtained from Youtube™ demonstrating the common walking patterns of older adults.

3.3 Getting Students Involved in Smart Health Technology Projects

During the laboratory sessions, the teaching staff used their existing Smart Shoe project for older adults to stimulate thinking of students. The smart shoes detected any changes in walk stability of older adults during their long-distance walk and gave appropriate feedback based on their real-time detections. Students formed groups during the class to discuss the future directions of the projects. They were asked to report 1) what exact health problems the shoes could address, 2) why they thought these were significant, 3) how technology could be used to achieve their aims, and 4) the difficulties they foresaw. Students were encouraged to use their computers or smartphones to perform rapid search for information during the laboratory session.

3.4 Flexible Choice of Student Topics

One major assessment (40% of total subject scores) was a group-project assignment, which required the students to identify a neuro-musculoskeletal disorder of their interests, present existing technology used to alleviate the disorder, discuss the theory behind using appropriate medical and engineering terms, and suggest improvements. Students formed groups of 3-4 students. To ensure their topics align with the teaching aims of the subject, the students discussed their selected topics and discussed with the teaching staff during the class in week 3.

3.5 Feedback through Online System

The students submitted their group-project assignments through Blackboard Online system (Blackboard Inc., Washington D.C., United States). They were required to submit an article showing the outline and some concrete information of their project in week 6. The teaching staff provided suggestions for improvements to individual group through the online system. Students were asked to revise their articles following the suggestions. Face-to-face discussion was arranged in week 11 to provide further suggestions to the revised article, before the final drafts were submitted in week 13. Instead of telling the students exactly what they should do, feedbacks from the teaching staff mostly involved questions which aimed to guide the students the possible ways of refining their projects. The Blackboard system generated email reminders of submission deadlines. Online forum was available which allowed the students and the staff to exchange ideas and information at any time.

4 Students' Performance and Feedback

Students' Performance. The students were assessed by Group projects (40%, also detailed in sections 3.4 and 3.5) as well as assignments and quizzes (60%, submitted by each student which assessed background knowledge of rehabilitation engineering). At the end, all students passed the subject. 11% of students received an overall rating of Excellent (Grade A or A+), and 67% received Good or Very Good ratings (Grade B or B+). Students generally performed well in group projects. They attained a mean ($\pm$ standard deviation) score of 34.1 ± 4.1 . Wider variability in scores (39.3 ± 13.2 out of 60) was observed in assignments and quizzes, which evaluated individual achievements.

Students' Feedback. In week 13, students were administered an online student feedback questionnaire by an administrative staff. Twenty-four students responded to the questionnaires (88.9% response rate). Figure 1-3 shows the findings regarding the subject, the teaching staff as well as overall learning experience. A majority (>70%) of students strongly agreed that 1) the staff member encouraged students to ask questions and discuss ideas in class, 2) the staff member encouraged to find information on their own and learn independently. Over 60% of students strongly agreed the teaching of the staff member has provided them with a valuable learning experience. The mean scores in each of the 11 assessment items reached top 10% of the entire Faculty of Engineering. In addition, a majority (63%) of students reported they spent on average 8-13 hours per week on studying the subject. Most students (88%) thought the workload for this subject was appropriate, with the remaining 12% of students commenting the workload was too heavy.

Written feedback from students included:

- “Give us many comments which are most helpful”
- “Staff member's interaction with students has helped my learning”
- “The assessments and feedback were most useful to my learning”
- “Able to know the rehabilitation technologies better”
- “Demonstrations on new prototypes are very helpful”

ABOUT THE SUBJECT

Your Learning Experience of the Subject

Item	Mean	Std Dev
1. I have a clear understanding of what I am expected to learn from this subject.	4.5	0.5
2. The teaching and learning activities (e.g. lectures, discussions, case studies, projects, etc.) have helped me to achieve the subject learning outcomes.	4.5	0.7
3. The assessments require me to demonstrate my knowledge, skills and understanding of the subject.	4.5	0.6
4. I understand the criteria according to which I will be graded.	4.5	0.6

5=Strongly agree; 4=Agree; 3=No strong view; 2=Disagree; 1=Strongly disagree

Fig. 1. Students' feedback about the subject.

ABOUT THE STAFF MEMBER

Teaching of the Staff Member

Item	Mean	Std Dev
1. The staff member's teaching was well-organised with clear presentations.	4.6	0.5
2. The staff member was helpful.	4.6	0.5
3. The staff member gave useful and timely feedback on my work.	4.7	0.5
4. The staff member encouraged students to ask questions and discuss ideas in class.	4.7	0.5
5. The staff member encouraged students to find information on their own and learn independently.	4.7	0.5

5=Strongly agree; 4=Agree; 3=No strong view; 2=Disagree; 1=Strongly disagree

Fig. 2. Students' feedback about the teaching staff.

Fig. 3. Students' overall impression.

5 Discussion

5.1 Technology-supported and interactive teaching in motivating students to learn

E-learning could facilitate active learning, which motivates students to learn [9]. A previous study also found active learning to be able to enhance students' performance in Science and Engineering [10]. This mode of learning involves students to engage in problems that involve higher order thinking tasks such as analysis, synthesis and evaluation [11]. To facilitate active learning, a balance should be struck between providing adequate support and challenge [12]. This could be supported by adoption of technology in teaching and learning. Use of websites to obtain medical knowledge and videos to further explain physical effects of the medical problems are good examples to this. Active learning could be further enhanced by providing students with some challenging questions, which require students to actively look for solutions using the internet and other sources. Allowing students to flexibly select a medical topic could align with students' interest, and a previous study has reported that students' academic motivation was dependent on their interest. Efforts should be made to help students to find the right information from the internet and other sources, and be able to interpret the collected information correctly. This can be supported by conducting academic assessments in the middle of the semester and providing feedback to students. Giving feedback to students is important, as a previous review stated that feedback was the most powerful single influence to student achievement [13]. And indeed many positive comments from students are related to the comments and feedback from the teaching staff. But resource constraints could lead to decline in quantity and quality of assessments and feedbacks. Providing feedback to group projects could save some manpower resource. In addition, online forum allows lecturers to provide feedback in a more casual way. To provide fair assessment, some assignments and quizzes should be arranged to test individual capability. Students have different learning characteristics, prior knowledge,

personal needs and motivation. E-learning enables students to learn at their own pace, which is particularly useful in teaching a group of highly diversified students.

5.2 Implementation in Other Levels of Courses

While the subject was taught at master-degree level, it can be implemented in undergraduate level. Previous pilots have suggested the high feasibility of enabling undergraduate students with different academic background to address biomedical problems together [6,14]. Engineering students require medical knowledge to enable them to use technology to solve health problems. However, their learning is different from medical students. While medical students have to systematically learn every aspect of a wide range of medical disorders, engineering students should learn the proper or pragmatic ways to obtain and interpret information when they are presented with a medical problem. Appropriate use of internet information to retrieve medical information could be one important aspect for engineering students to learn, and future research could identify better and easier ways of assessing correctness of internet-based information. To enable students to confront real-life problems, teaching staff may engage students to existing research projects. If they do not exist, students could be encouraged to review the existing engineering solutions to medical problems, identify limitations and propose improvements. The subject presented in this paper facilitated engineering students to learn about the use of technology in rehabilitation aids for people with physical disability. Similar teaching approaches may be applied to guide students to use engineering solutions to prevention, diagnosis and treatment of diseases.

6 Conclusion

This paper presents the use of e-learning and some other interactive teaching approaches to facilitate master-degree engineering students to learn biomedical devices and technology. Similar approaches may be applied to undergraduate courses to enable engineers to have an option to work in the fast growing medical industry.

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