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Development of Case-Based Learning (CBL) in Engineering Technology Education*

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Case-based learning (CBL) is an active learning technique that has traditionally been underutilized in engineering technology education research. Real-life case studies were developed and used in teaching and learning two biotechnology courses in winter 2019. The overall student evaluation of CBL was positive: 71% of students agreed that CBL enhanced their learning, while 13% disagreed and 16% of students were neutral. 74% of students found that CBL helped them in team working skill and 24% were neutral. Detailed evaluation and discussion of CBL enhancement on problem solving, critical thinking, learning experience and technical skills are carried out in this study.

Keywords: active learning, experiential learning, engineering technology, education, biotechnology

1. Introduction

Biotechnology is a multidisciplinary field of study consisting of several sub-disciplines from bioscience, engineering, and business (Fig. 1). Case-based learning (CBL) is a method of active learning that can link all these disciplines together and connect them to industry practices. Real-life cases can be used to enhance teaching and learning as well as increase student participation in classroom discussions.

With dynamics rapidly changing within bioindustries and technology, students need more effective learning approaches to help link course concepts with real-life industry application to build and enhance the required skills for workplace coop placements and future career opportunities.

CBL is a commonly used active learning tool in business, law, and medical education to replace traditional teaching with didactic teaching methods. Learning and remembering in medicine are easier when linked to patient cases [1].

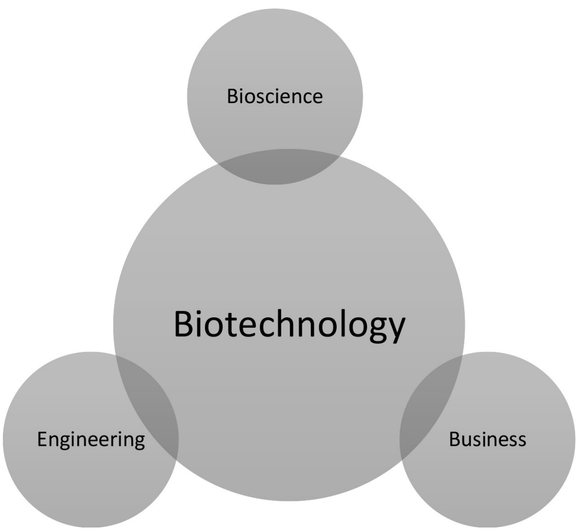

Fig. 1. Multidisciplinary nature of biotechnology curriculum.

CBL has become more popular as a methodology in education research [2–5]. This could be due to several factors, from the increased interest in all forms of qualitative research to the proliferation of case studies used in education classes. As the pedagogical use of CBL, popularized by the Harvard Business and Medical Schools, has become more prevalent across various education disciplines [6, 7], educational researchers have gained awareness of the viability and complexity of case studies. CBL, as used for pedagogical purposes, takes its inspiration from case study research. They tell the story of particular educational events in context so that novice teachers can understand the complexities of analysis and the possible search for solutions. Yin [5] defines CBL methodology as empirical inquiry investigating contemporary phenomena within their real-life contexts, when the boundaries between phenomena and context are not clearly evident, and in which multiple sources of evidence are used.

There are relatively few articles dealing with the use of case-based learning in engineering technology education as compared to science, medicine, business, and law education. Vivas and Allada [8] used thematic CBL to enhance engineering education and developed three industry case studies. They found that thematic case studies could fill the gap between theoretical background and practice. Case-based instruction was also used in teaching innovation theory for engineering technology students [9]. Yadav et al. used case study based instruction with mechanical engineering undergraduate students [10, 11].

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2. Methodology

This is a pedagogical study on the development and application of CBL in engineering technology undergraduate education. The study focused on the application of CBL on two biotechnology program courses in winter 2019. Blended teaching and learning were used throughout this study by alternating between traditional lectures and, active learning techniques such as case studies. The total number of students (n) in this study was 62, 31 in each course.

Effectiveness of CBL measured students' perceptions based on an anonymous survey questionnaire evaluating critical-thinking, problem-solving, teamwork, real-life technical and communication skills. Students responded to questions on a five-point scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, to 5 = strongly agree).

3. Results and Discussion

3.1 Effect of CBL on Critical Thinking

Fig. 2 shows students' responses to the effect of CBL on critical thinking. Sixty-four percent of students agreed that CBL improve their critical thinking (29% strongly agreed and 35% agreed). However, 13% of students disagreed (10% strongly disagreed and 3% disagreed) and 23% were neutral. This result indicates that CBL enhanced most students' critical-thinking and multiple-ways-of-thinking skills, supporting the conclusions of previous studies [12].

3.2 Effect of CBL on Problem Solving

Fig. 3 depicts CBL's effect on problem-solving skills; 54% of students agreed that CBL helped them in problem solving (19% strongly agree and 35% agree); 17% of students disagreed (7% strongly disagreed and 10% disagreed); and 29% were neutral. Kaur et al. [13] reported that 71% of dental surgery students found CBL helped them in solve clinical cases in better way. However, this difference may due to differences in student demographics and disciplines.

3.3 Effect of CBL on Teamwork

The effect of CBL on teamwork is shown in Fig. 4.

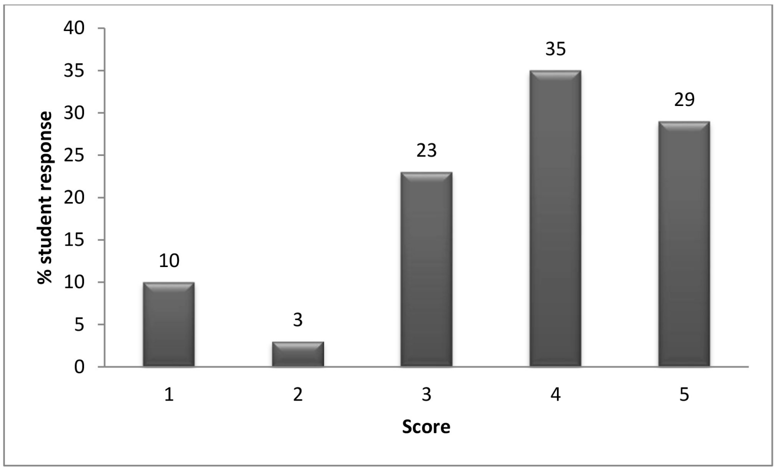

Fig. 2. CBL improved my critical thinking. Score 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree.

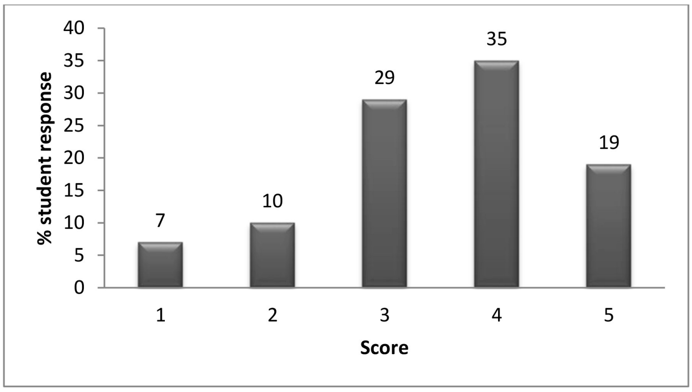

Fig. 3. CBL helped me in problem solving.

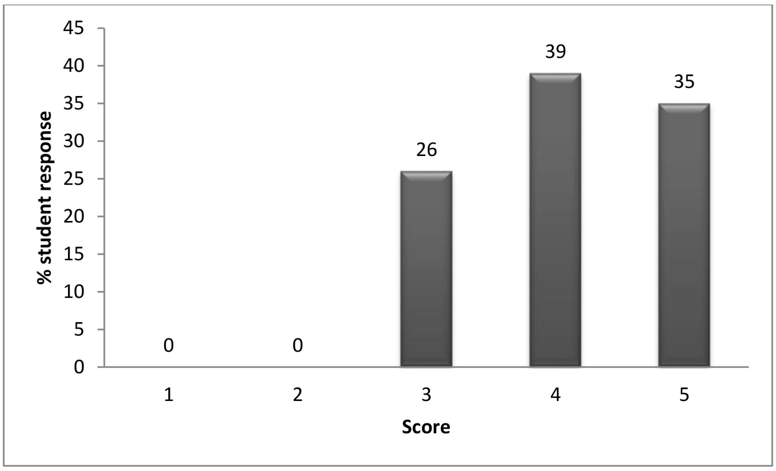

Fig. 4. CBL helped in teamwork.

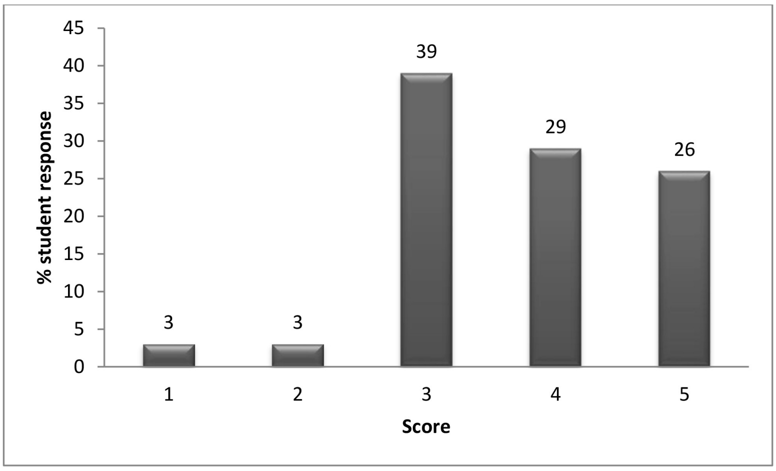

Fig. 5. CBL improved my communication skills.

Most students (74%) agreed that CBL helped them build teamwork (39% agreed and 35% strongly agreed), while 26% were neutral. This is the only parameter with no disagreement (0% disagreed). Because students were working in teams of three during the application of CBL, they consistently practiced teamwork during their classes.

3.4 Effect of CBL on Communication Skills

Over half (55%) of the students agreed that CBL improved their communication skills (29% agreed and 26% strongly agreed), while 39% were neutral and 6% disagreed (Fig. 5). These results support the fact that CBL has a positive effect on oral and written communication skills compared to other methods of teaching and learning, as established in the existing literature [14].

3.5 Effect of CBL on Real-Life Technical Skills

Fig. 6 shows that 50% of students agreed that CBL improved their real-life technical skills, while 17% found that it did not improve their technical skills and 33% were neutral. CBL enhances technical skills through discussion, simulation, and reflection [15].

3.6 Overall CBL Evaluation

The overall evaluation of CBL in Fig. 7 reveals that 71% of students agreed that CBL was useful as an active learning technique, while 13% did not find it useful and 16% were neutral.

These results agree with Boony's [14] findings that 89% of surveyed students felt that CBL was better than didactic lecture in understanding the topic.

There are many challenges in applying CBL to curricula, such as student's lack of familiarity with CBL, connection between CBL and theoretical concepts, case complexity, and type of case questions [15]. When those challenges are addressed, students' overall evaluation of CBL may improve. However, engineering instructors must interpret with care student perceptions about their learning

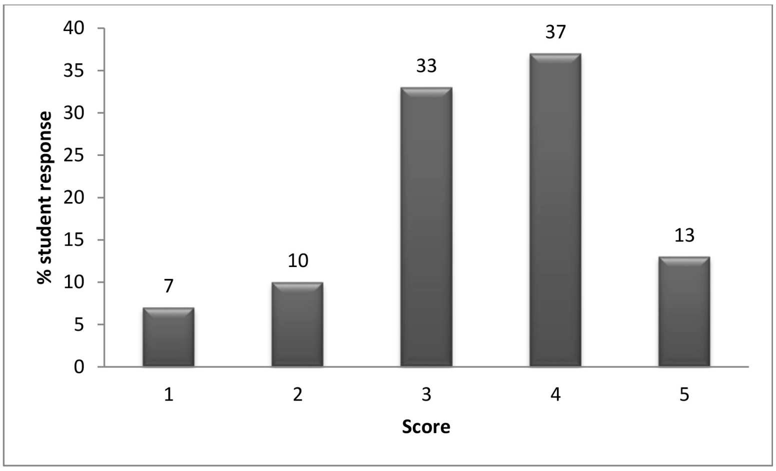

Fig. 6. CBL improved my real-life technical skills.

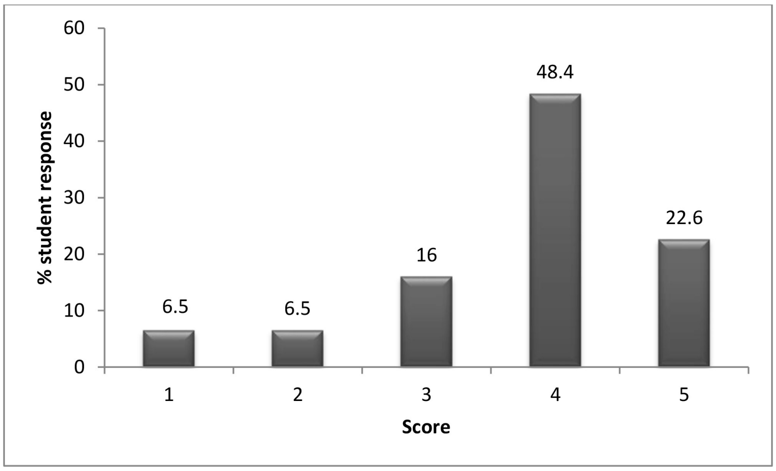

Fig. 7. Overall student evaluation of CBL.

outcomes when assessing curricula development [11].

4. Conclusions

This study highlights the importance of CBL as an active learning technique in the teaching and learning process of an interdisciplinary field of study such as engineering biotechnology. It was found that CBL improved most students' critical thinking and helped them in problem-solving, team work, communication, and real-life technical skills. Further studies on the application of CBL to other courses are required, along with work to determine the effects of CBL on students' performance.

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