Factors that Influence Multidisciplinary Teamwork in a Challenge-Based Learning Course

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ABSTRACT

For our students to work on the global challenges facing humankind, they should be raised to appreciate the importance of science and engineering in real-life contexts. Challenge-based learning (CBL) courses have merit in accomplishing this goal by facilitating students' innovative solutions to authentic, complex problems. The fundamental characteristics of CBL include real-world challenges, collaboration, and multidisciplinarity. The presented work describes a CBL course where applied physics and mechanical engineering students worked in multidisciplinary teams. An instrumental case study was conducted to identify factors that influence multidisciplinary teamwork in this CBL course. Data were collected using interviews, reflection reports, and observations of team meetings. Transcribed video recordings were searched for instances of demonstrating the codes revealed with analysis of interview transcripts and reflection reports. The research results showed the significant factors influencing multidisciplinary teamwork: a) disciplinary connections to the challenge, b) receiving tutor guidance, c) making presentations in teams, d) exchanging science and engineering perspectives, e) readings and videos on course Canvas, and f) student motivation. Implications are discussed, and suggestions for future research and practice are presented.

1 INTRODUCTION

Learning environments that address multiple disciplines have the potential to contribute to learning and to develop competencies such as critical thinking, problem solving, communication, and an awareness of societal problems [e.g., 1, 2].

Approaching an overarching theme or a problem with the knowledge and methods of multiple disciplines lies at the core of challenge-based learning (CBL) courses [3]. A recent systematic literature review revealed one of the core characteristics of CBL as multidisciplinarity [4]. In a CBL course, students work on real-world challenges such as food safety and sustainability as they gain or deepen knowledge and skills [3].

Having students work on challenges in multidisciplinary teams is a common practice in CBL courses [e.g., 1]. In multidisciplinary teams, students apply the knowledge and methods of their disciplines to communicate and to solve open-ended problems [5]. Multidisciplinary teamwork in CBL and similar project-based courses in higher education is evidenced to have positive impacts on students' skills development and learning of course content [e.g., 6].

This study addresses the need to identify factors influencing multidisciplinary teamwork in the context of the first pilot of a CBL course.

1 METHODOLOGY

1.1 Design

A case study approach was adopted to explore multidisciplinary teamwork in the course context [7].

1.2 Participants and data collection

The CBL course; “CBL Systems and Control” was designed to use the knowledge and methods of applied physics (AP) and mechanical engineering (ME) around the specified challenge: design and implement a real-time controller for a pick-and-place robot’. The hardware in used in the course was a robot arm set-up shown in Figure 1. The course included 30 second-year bachelor students. There were seven AP and 23 ME students who worked in teams. Each of the five teams consisted of six students. Data were collected from students (*n* = 12) and from the teacher team (*n* = 5).

Semi-structured interview questions were prepared considering the literature on factors that influence successful teamwork. In addition to the interview responses on the already existing conditions perceived as factors, participants also commented on how to address multidisciplinary teamwork in the course more effectively. Data also included students’ individual reflection reports on their teamwork experiences. The reflection reports were collected at the end of the course.

Video recordings of team meetings were used to supplement the results of the interviews and the reflection reports.

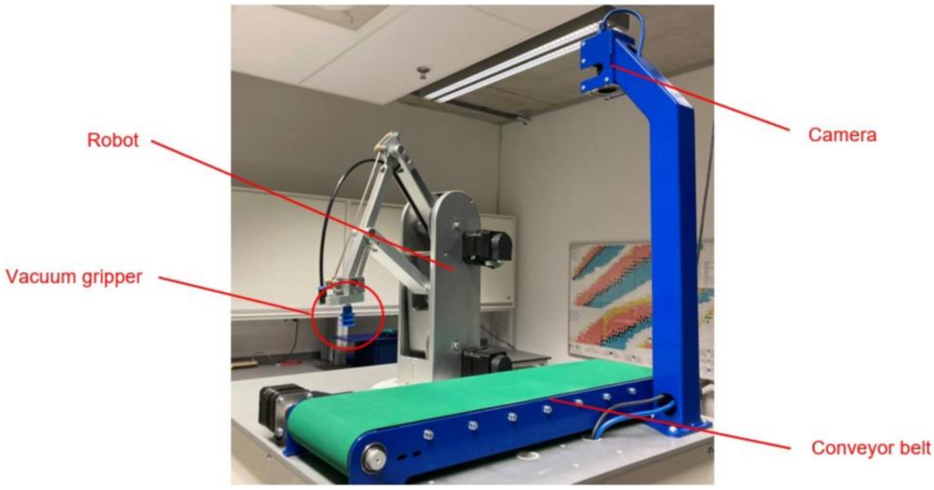

Fig. 1. Robot arm in the lab.

1.3 Data analysis

The qualitative analysis of the interview transcripts and the reflection reports revealed a codebook following a content analysis method [8]: 1) initial screening of data, 2) identifying themes and codes based on repetition and relatedness, and 3) finalizing the codebook with frequencies and percentages.

2 RESULTS

The results were sumarized in three categories: (a) individual factors (31%), (b) team factors (29%), and (c) contextual factors (40%).

For individual factors, findings revealed that *lack of pre-knowledge of control theory* (61%) acted as a barrier for multidisciplinary teamwork. ME students had to explain AP students about control theory in the first weeks of the course. Although the results indicated that *using online course materials* (17%); the lectures and videos on the course learning management system; Canvas was helpful in improving the necessary knowledge, the knowledge gap between AP and ME students were frequently addressed. An exemplary response was: *"AP students could catch up with the knowledge at the end of the project that let more ideas…Similar level of knowledge would have saved some time for teamwork."* The findings also revealed *prior experiences* (22%), team experience and experience in robotics as facilitators of multidisciplinary teamwork.

For the team factors, *communication* (41%) emerged as a facilitator of multidisciplinary teamwork. The video transcripts demonstrated team members' comfortably expressing their ideas and asking questions. *Exchange of disciplinary perspectives* (28%) between AP and ME students was suggested as another important facilitator of successful teamwork. One exemplary response was*: "…we were stuck in the methods part….and they (AP students) brought a different view to the project...".* Next, *making presentations* (16%) considering the presence of students from the other discipline facilitated teamwork.

The findings showed *the disciplinary connections of the design challenge* as the most significant contextual factor for successful multidisciplinary teamwork (54%). Results indicated that the design challenge, mainly drawing knowledge and methods from ME compared to AP was a barrier for teamwork. A teacher comment illustrated this point: *"I think the challenge being skewed to ME makes it tough in this case, to really guarantee that you can get the added benefits from both disciplines…"* Finally, *tutor guidance* (26%) is found to contribute by extending discussions where AP and ME students offered different insights.

3 SUMMARY

This work presents novelty by: a) presenting an example multidisciplinary CBL course and b) reporting suggestions on how to better promote multidisciplinary teamwork. An important conclusion is that although the disciplinary connections of the challenge task allowed for an exchange of disciplinary perspectives between AP and ME students, the challenge can benefit from a stronger connection to AP concepts. This suggestion is also related to the identified barrier; a gap on prior knowledge on control theory. The emergence of barriers to multidisciplinary teamwork, such as limited disciplinary connections and gaps in prior knowledge, can also be explained by the first piloting of a newly designed course. An improved understanding of the facilitators of and barriers to multidisciplinary teamwork can enhance the functioning of the teams and thus foster student learning in similar courses.

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