INTEGRATION OF CBL IN THE MSC ROBOTICS PROGRAMME AT THE UT – THE IMPLEMENTATION AND FIRST RESULTS

H J B Muijzer-Witteveen[1], E M P Hermsen[2], O Karageorgiou[1], J F Broenink[1]

[1]MSc Robotics programme, University of Twente,
Enschede, THE NETHERLANDS
h.j.b.witteveen@utwente.nl
o.karageorgiou@student.utwente.nl
j.f.broenink@utwente.nl

[2] Centre of Expertise in Learning and Teaching (CELT), University of Twente,
Enschede, THE NETHERLANDS
eduardo.hermsen@utwente.nl

ABSTRACT

Challenge-Based Learning has been implemented in the newly started MSc Robotics programme at the University of Twente to better prepare students for their MSc-thesis project and their future career. A robotics flavoured variant has been created, based on the general CBL framework. The key elements of this robotics variant include: (1) the requirement that the end solution should be a robotics solution, (2) the framing of compulsory robotics courses towards the challenges, (3) four umbrella CBL projects over the first year, (4) multi-disciplinary groups of students with different backgrounds (5) increasing complexity of the projects, (6) different foci per project, and (7) support by student CBL coaches. Course-specific elements are being assessed and graded within the courses. The CBL-specific elements (description and reflection on CBL process, teamwork, and personal learning goals) are stored in the portfolio written by the students. Formative feedback is provided at the end of each project based on the portfolio and only at the end of year 1 a pass or fail grade is given.
The first group of 32 students, divided over 6 groups, have finalized their first two CBL projects. Evaluation is being done involving the students, CBL coaches and teachers, and the CBL teachers. The overall opinion is that the CBL in the MSc Robotics programme is appreciated, but the integration between the courses and the CBL projects needs some more alignment.

Keywords*: Challenge-Based Learning, robotics, master programme, implementation, evaluation*

1 INTRODUCTION

In September 2022 the MSc Robotics programme has started at the University of Twente. The setup of a completely new programme provides a great opportunity to introduce new teaching and learning methods, of which Challenge-Based Learning (CBL) is one of them.

There are two major reasons for the implementation of CBL within the Robotics curriculum: To better prepare students for (1) their MSc-thesis project, and (2) their future career.

Experiences in existing MSc programmes showed that many students encounter problems during their MSc-thesis projects. By going through the CBL phases in several projects, it is expected that students will become more used to setting up their own research and defining the right research questions.

The field of Robotics is by itself a multi-disciplinary field, combining electronics, mechanics, control, and computer science. By working in multi-disciplinary groups, where knowledge from different disciplines should be combined, the students will be better prepared for their future work. Furthermore, by starting off from a big idea related to the current issues in society, the students are being prepared for working on real-life projects.

The implementation of CBL in the MSc Robotics programme relates to the following aspects of the programme's intended learning outcomes: (1) Integrate specialized advanced knowledge; (2) working in a multi-disciplinary team/environment and communicate to specialists and laymen; (3) develop a broad scope with respect to ethical, legal, social, and economical (ELSE) aspects; (4) devise and realise personal goals and reflect on it.

Sticking to the more general key elements of CBL; going through the 3 phases of the CBL framework (The Challenge Institute, n.d.), starting from an abstract big idea, involvement of external stakeholders, working in multidisciplinary teams, and a focus on reflection, a robotics-flavoured CBL variant has been introduced in the MSc Robotics curriculum.

A focus on student learning and curriculum design elements described by among others (Rådberg et al., 2018) formed the basis for the implementation of CBL in the MSc Robotics.

2 METHODS

The key features of the implementation of CBL within the MSc Robotics programme are discussed below.

2.1 Robotics framing

The strongest restriction that was put on the CBL concept was that it had to fit with the intended learning outcomes of the programme and the involved courses, and therefore it is stated that each end solution of the CBL projects should be a robotics end solution.

Furthermore, the student groups should integrate the knowledge they acquire in their Robotics courses in their CBL project. The course teachers define these course-specific elements.

2.2 Covering the whole programme

CBL within the MSc Robotics programme consists of 4 CBL projects in teams in year 1 of the programme. In year 2, consisting of an internship and MSc-thesis project, students work individually and reflect on the use of CBL in their projects.

2.3 Umbrella over the first year

In each quartile there is one CBL project that covers the compulsory courses that are given in that quartile. There are 1 or 2 compulsory courses per quartile. 20% of the time of each compulsory course is allocated to work on the CBL project, including the meeting time, portfolio writing, and the incorporation of the course-specific elements.

2.4 Course-specific elements

The course teachers of the compulsory courses define which part of the course content should be incorporated in the CBL projects. This framing towards the compulsory courses must be taken into account by the students in their challenge definition.

2.5 Multi-disciplinary teams

Student teams of 5-6 students are formed by mixing the backgrounds of the students. Backgrounds are the BSc programmes the students followed (mechanical engineering, electrical engineering, advanced technology, etc.), but also the different specialisations and profiles within the MSc Robotics programme. The different profiles (Research, Design, and

Innovation & Entrepreneurship) indicate their proposed future career path, while the three specialisations focus on three main elements of robotics: mechatronics, software, and human-robot interaction.

2.6 CBL coaches and teachers

The student teams are being supported by CBL coaches. These coaches are student assistants who not necessarily have a background in robotics but do have experience in CBL work. In this way, the support is really on the CBL level, guiding the students through the process, while questions on the content are handled by the course teachers.

The coaches are being guided by the CBL teachers. Coaches and teachers meet on a weekly basis and discuss questions that arose during the projects, but also define the coaching strategy for the coming period.

The CBL teachers are responsible for the assessment. Input from the CBL coaches is taken into account in this process.

2.7 Increasing complexity over the CBL projects

To optimally guide students in their CBL process, scaffolding (MacLeod & van der Veen, 2020) is implemented. The first CBL project can be seen as an introduction project. There is an introduction lecture on the key features of CBL, the engage phase is longer to get used to the team and the CBL way of working, there is extra support by the CBL coaches to discuss personal learning on an individual basis, there is only one course involved, and there is no active stakeholder involvement.

After the first CBL project, the complexity of the projects increases by increasing the stakeholder involvement, increasing the number of compulsory courses involved in the project, and by decreasing the support by the CBL coaches.

2.8 Different foci per project

Next to the increase in complexity, the CBL projects also have different foci per project. In each project the focus is on a different CBL phase; (1st project engage phase, 2nd investigate, 3rd act, and 4th open to the students to decide the focus). The focus on the CBL phases is expressed in more time allocated for the specific phase.

Also the focus on possible interactions is adjusted per project. For the first project the focus is on the personal role within a team, while in the second project the focus is on the interaction between team members, in the third on cross-team interactions, and in the fourth on interactions with external stakeholders.

2.9 Assessment

The course-specific elements of the project are assessed by the course teachers and part of the final grade for the courses.

Assessment for learning is an integral part of CBL during the year and part of the instructional design with elements of feedback, self-regulated learning and motivation (Wiliam, 2011).

The CBL-specific elements of the project are stored in an individual portfolio consisting of four elements: (1) description of the CBL process, focusing on the steps taken and reasoning

behind, (2) description and evaluation of the teamwork, (3) a personal work and learning plan, showing the personal learning goals and the reflection on it, and (4) the product portfolio, linking to the end product of the CBL project.

The first three elements of the portfolio are part of the assessment rubric that is constructed for each CBL project. Based on this rubric the student receives formative feedback for each element. This feedback, given by the CBL teachers, can be on three levels: (1) needs attention, (2), on track, and (3) stands out.

Feedback from previous projects should be taken into account by the students in their next projects. After the fourth project, the performance in all projects is summarized and assessed by the CBL teachers, resulting in either a pass or a fail for the students.

3 RESULTS

The MSc Robotics programme has been running for 2 quartiles now with 32 students divided over 6 groups. For the second quartile the evaluation is not completed yet.

To evaluate the quality of the CBL implementation in the master's programme, a multi-level evaluation took place through surveys, interviews and panel meetings with students, CBL teachers and coaches. Evaluating the implementation of CBL in the programme, the involvement of the stakeholders, and the experience and learning development of the students. The results revealed that CBL was perceived positively by all involved members overall, but that there is space for improvement regarding implementation and integration to the core curriculum.

4 CONCLUSIONS

Although the implementation of CBL in the MSc Robotics is appreciated by students and teachers, the following attention points became clear:

(1) ECs could be explicitly dedicated to the studying hours of CBL, and the workload between CBL work and the assignments from other courses should be equally or proportionately divided.

(2) Proper preparation on the CBL practices and methods should be offered to all involved teachers to ensure optimal incorporation in their courses.

(3) The involvement of the stakeholders is crucial for the best involvement of the students and the shaping of the challenge.

(4) Finally, the introduction of student assistants as coaches lowers the threshold for the students to approach for questions, and ask guidance, which supports their learning process.

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