Work-In-Progress: Perceived learning gains of students, teachers and domain experts in Challenge-based learning and students' critical thinking activity in student - domain-expert interactions

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Summary

What do students, teachers and domain experts learn from engaging in a Challenge-based learning (CBL) project? And to what extent do domain experts foster critical thinking in students? These questions were addressed in a research study that took place in the context of the 2021-2022 semester 2 project of the ATLAS program of the University College Twente, part of the technical University of Twente in the Netherlands. The project theme was "Sustainable Oceans" and the assignment for the students was to write a short-term and long-term socio-technical scenario for an emerging technology related to the theme. In this project, 28 first-year students, 5 ATLAS tutors, and 6 domain experts from industry, research, and society participated. The main research questions were: what do all stakeholders in this CBL project perceive as their main learning gains from participating in this project? And to what extent were the domain expert able to foster critical thinking activity in students? Data was collected using surveys, interviews, audio recordings of student-expert meetings and student focus groups. Preliminary results show clear learning gains for all stakeholders, even though challenging issues in the collaboration process were identified.

Key words: CBL, interdisciplinary project, domain experts, critical thinking

Type of contribution: Research extended abstracts

Introduction

The University College Twente, part of the technical University of Twente in the Netherlands, hosts a unique Bachelor program, ATLAS (Technology, Liberal Arts and Sciences). This three-year bachelor program focuses on educating New Engineers who can approach complex issues from different disciplinary angles (mathematics,

natural sciences and social sciences) in a multi-stakeholder collaborative context. ATLAS is a breeding ground for innovative teaching approaches. The program adopted the concept of self-directed learning, meaning that students set their own learning goals and self-evaluate their academic performance to build their unique profile as a New Engineer. ATLAS provides for a foundation in mathematics, natural science and social sciences, and CBL semester projects in which the students work together on mitigating complex societal issues. The extensive elective space accommodates the build-up of a unique profile as a New Engineer.

The 2021-2022 semester 2 project revolved around the theme "Sustainable oceans." The challenge was to choose a technology related to Biotechnology, Energy or Transportation and develop a long - and short-term sociotechnical scenario that would show how the technology could become mainstream. Teams of 5 – 6 students were assigned two domain experts, and two tutors with expertise in social and natural science. In the 2020-2021 run of the project, students would meet regularly with their tutors for feedback on project deliverables and to discuss important steps in the project. The domain experts' role was to open the door to real-life contexts and provide information on state-of-the art technology development. However, it appeared that the domain experts did much more than that. With financial support from the University, it was decided to explore learnings gains of all stakeholders involved in the current set-up, with a special focus on critical thinking in students.

Challenge-based learning as an educational approach is becoming increasingly popular in higher education institutes, especially in engineering education (Gallagher & Savage, 2020). In the Netherlands, most of the technical universities have currently adopted the approach. Despite its popularity, there is still a need for research on student voices, praxis, and evidence on learning with respect to CBL (Leijon, 2021). This study responds to this call. Although there is evidence that knowledge gains of students in CBL are substantial (Caratozzolo & Membrillo-Hernandez, 2021), this study also explored teachers' and domain experts' leaning gains. In addition, the study focused on the extent to which domain experts played a role in fostering critical thinking activity in student. There is evidence that suggests that CBL can foster critical thinking (Nawawi, 2017) and that involving industrial partners in the learning process has an added benefit for student learning by increasing complexity and uncertainty levels (Membrillo-Hernandez et al., 2019). This suggests that interactions with domain experts can foster critical thinking activity in students.

Our main research question was: what do all stakeholders in this CBL project perceive as their main learning gains from participating in this project? And to what extent are domain expert able to foster critical thinking activity in students?

Methods

The project team received a grant from the University of Twente to conduct the study. The Ethical Committee approved of the plan. To study perceived learning gains of teachers and domain experts, semi-structured interviews were conducted. For the learning gains of the students, short surveys and focus groups were used. To study the assumed effect of domain expert interaction on students' critical thinking ability, verbal protocols of expert meetings were analyzed. Based on work by Facione (1990) it was assumed that the following critical thinking activities would be fostered by the domain experts: Assumption recognition, Argumentation, Evaluation and Decision making. In addition, focus groups were used to further explore this assumption.

Results

Currently, data analysis is being completed, so only preliminary data will be described here. We will first address students' perceived learning gains, followed by tutor and expert's learning gains. Finally, we will address critical thinking.

Regarding the student perceived learning gains, the data indicated that the main benefit of having experts available was in bringing together real-life knowledge and insights from the experts, and the academic perspectives of the students on the project topic at hand. This closes a gap that is usually present between academic and real-life settings. The experts supported students in broadening the scope of the technology they researched and widened their perspectives on the broader context in which the technology would function. This resulted in a deeper understanding and awareness of the complexity of the technology and related stakeholder dynamics in society.

Students also pointed out that they learned from the different perspectives of the experts and the tutors, through discussing their different standpoints and perspectives. This fostered their decision-making skills, as they needed to evaluate information and decide what is relevant and what not for their projects. They also practiced critical evaluation of information and critical thinking skills by being questioned about the assumptions they made, and they felt the experts supported them in developing confidence and better organization of thought. Experts helped them develop their research (where to find credible information, how to assess it) and communication skills and students also experienced the challenge of understanding the different vocabularies used by experts from different disciplines around one topic. Finally, students pointed out that they improved their note taking skills (being able to write quickly, listen while typing, think, and participate in conversation).

Tutors highly appreciated the participation of experts in the project. They expressed having learnt a great deal about the project topics. However, they found students required additional guidance in relation to working with experts. For example, how they should evaluate what the experts bring to the table. They also noticed students are insecure (what path to take and how to move forward), and sometimes confused about the role and position of the experts (i.e. how much of experts' input they need to include, and to what extent experts were aware of students' general progress in the semester project). In general, tutors expressed they were positively surprised that first-years students are capable to deal with very complex issues and the multiple opinions of real-life stakeholders.

Tutors expressed that they became more open to the inclusion of experts in their own projects and classes. They also mentioned that, in such a case, they would try to define the experts' role more precisely. They also became more confident to trust the capacity of students to judge input they receive, but they would also encourage students to speak up more and be more confident in their interactions with domain experts. Finally, the inclusion of specific learning activities for the development of collaborative skills and team bonding which was part of the project, was a takeaway for the tutors.

The project experience was generally positive for all experts involved. They considered their main gain was learning about the technologies or the geographical areas chosen for the scenarios. On occasion, they expressed that the reference list of project reports was of use to them. Some of them expressed having gained a better

understanding of the breadth of the topic, learning about it from the perspective of another discipline. Finally, some of them did not work with students previously, and gained insights in what this entails. The main challenge they identified were the students' teamwork abilities.

When asked about what they took from the project for their own practices, they mentioned two aspects. Firstly, like all other stakeholders, the benefit of becoming aware of the complexity of certain problems and issues. Second, the benefit of incorporating multiple perspectives (from various disciplines and points of view) in dealing with challenges to create a holistic perspective on a given problem.

Finally, students expressed that the experts helped them develop their critical thinking skills, by asking them questions, bouncing off ideas and consistently asking them to look at their assumptions. From the audio recordings of the expert meetings there were few signs in this direction, but based on self-report measures and focus groups, it was evident that the experts helped the students develop their critical thinking skills. Based on the feedback students received from tutors and experts, they often revised their assumptions. On presenting their ideas to the experts, they experienced their argumentation and organization of thoughts improved. The expert meetings enabled them to engage in discussions with the experts about the topic and to carefully evaluate arguments to build their scenarios. Although not fully intentional, the experts helped the students sharpen their critical thinking throughout these activities, leading to what the students referred to as "accelerating the development of critical thinking skills." The students also mentioned that having two different experts helped fostering their critical thinking, especially regarding evaluating their assumptions.

Discussion and Conclusions

To complement the picture presented, it is fair to say that some challenges were identified as well. It became clear that involvement of various stakeholders (tutors and experts) calls for clear roles and task expectations. At times, experts expressed to be overburdened, and at times tutors and students found involvement of experts challenging as experts did not fully understand the learning objectives of the project. Students also sometimes asked contributions from the experts which were not agreed upon with project management beforehand, adding to the workload of some of the experts. So, clear role and task expectations seem important.

Another important factor seems to be the quality of the relationship between students and experts, this affects the effectiveness of their collaboration. In addition, the extent to which experts see students as active players in CBL dynamics instead of passive learners seems important in this respect.

For students, the degree to which they made use of the experts differed. There were groups who had over fourteen meetings with their experts, whilst some only had four or five. As it could not be controlled how many meetings the groups would have with their experts, therefore it is recommended for future research that the number of expert meetings is standardized.

Regarding the tutors, student perceived tutoring as very useful but experienced challenges in dealing with different tutoring styles (each group had at least two tutors). Even though there was a tutor learning community set up to share information and solve problems, not all teachers attended regularly. It is advised to encourage this to align tutor practices more.

In all, this challenge-based learning project was experienced as positive and enriching for all stakeholders involved. What we learned is that it is important to define clear roles and tasks for all stakeholders involved and to communicate them well. Furthermore, good project coordination is of seminal importance to temporally align all different learning activities and to distribute workload evenly.

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