Research Proposal Innovation Fund

Project Title:

Deepening Multidisciplinarity within Systems & Control: Second Pilot

Project Team:

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1.Introduction

1.1. Background to the Project

At Eindhoven University of Technology (TU/e), The collaborative project of the departments Applied Physics (AP) and Mechanical Engineering (ME) entitled: '3BYX0P – Challenge Based Learning (CBL) Systems and Control' had been granted for 2021-2022. In this project, AP and ME, collaborated to do the first piloting of a joint CBL course: '3BYX0P-CBL Systems and Control Project'. Empirical findings from its accompanying research project: 'Deepening Multidisciplinarity within Systems and Control' carried out by Eindhoven School of Education, together with the experiences of the teachers and the tutors led to the improvement of the course. In its second pilot, the teacher team worked on modifying the course considering, for example, a challenge that draws on more from AP expertise, keeping the presentations that students make during their team meetings, attracting more AP students to the course. In the second year of the project (2022-2023), the researchers of Eindhoven School of Education (Canan Mesutoglu, Dury Bayram-Jacobs, Annemieke Vennix, and Jan van der Veen) carried out research in the context of this revised CBL course, delivered in April-June, 2022.

This final report of the research project: "Deepening Multidisciplinarity within Systems & Control: Second Pilot" presents a summary of the research findings and conclusion.

1.1.1.Multidisciplinary Teamwork

One of the remarkable features of innovative learning environments is making students from different disciplines and stakeholders from various backgrounds collaborate to solve complex, open-ended problems. In today's world, the demand for graduates who are capable in working in multidisciplinary teams is growing (Sharma et al., 2017). The team members are expected to: a) identify their own skills and knowledge and their own contributions to the project, b) interact with the team members to clarify their disciplinary contributions to the project, and c) appreciate and synthesize other disciplines' knowledge in relation to the project outputs (Schaffer et al., 2012). It is important to have students work collaboratively on problems, specifically, to equip students with the competencies to function successfully in multidisciplinary teams (Lattuca et al., 2017). Having students work on problems in multidisciplinary teams is a common practice in CBL courses (Ktoridou et al., 2016).

1.2. Purpose of the Project

TU/e describes the engineer of the future as an individual who can function effectively in collaborations of multiple disciplines. The vision statement highlights (TU/e Strategy 2030, 2018): "…a new type of public-private partnership where interdisciplinary teams of people from multiple organizations work together in specific projects to bridge the gap between scientific findings and commercial development" (p. 4). CBL (Challenge-Based Learning) has merit in accomplishing these goals as it draws on the knowledge of multiple disciplines in providing solutions to real-world problems (Gonzalez-Hernandez et al., 2020). The renewal of bachelor education at TU/e is putting a focus on "educating the 'future proof' engineer: an engineer who not only now but also in the future can come up with technological solutions for challenges that arise in the world." (TU/e, 2018).

The purpose of the project was two-fold: a) to take a closer look at the teamwork of AP and ME students in the context the second pilot of the CBL course, and by doing that, to explore how the two disciplines are coordinated and communicated and b) to investigate the perceived usefulness of the course for the students.

2.Method

2.1. Research Design

The "Deepening Multidisciplinarity with Systems and Control" project used qualitative data to address its purpose. More specifically, a case study approach was adopted, to gain a comprehensive picture of the boundary processes in multidisciplinary teams as part of the revised CBL-Systems and Control course (Fraenkel et al., 2012, Yin, 2014). Table 1 presents the data collection and analysis.

The context of the research, the nine-weeks elective CBL course, included 18 students in total. Among them, four were AP and 14 were ME students. Each of the two multidisciplinary teams included two AP students and four ME students, leading to 12 students for the sample of this research.

Table 1. Data collection

	Data Collection	**Data Analysis**
Boundary processes in multidisciplinary teams.	Reflective journals, interviews with students of the two multidisciplinary teams (*n* = 12)-audiotaped, observations of team meetings-videotaped.	Qualitative data analysis: First cycle and second cycle coding (Miles & Huberman, 2014).
	Data Collection	**Data Analysis**
Perceived usefulness of the course.	Student interviews (*n* = 18)- audiotaped.	Descriptive analysis, noticeable patterns are identified.

3.Results

The findings of the project are presented in two sections in line with the research focuses.

3.1.Boundary Processes in Multidisciplinary Teams

The findings put forth the disciplinary aspects of AP and ME that surfaced and interacted during teamwork. As can be observed on Figure 1, ME students contributed to teamwork and thus the design of a solution in response to the given challenge, with their: a) efficiency and communication skills, b) content knowledge of control theory, c) a practice-orientation, and d) knowledge on applications of control theory. A quotation for the practice-orientation was as follows: "ME had a very pragmatic approach to everything... ….a really big difference with AP…which I think is a good balance to have." To continue, AP students are founds to have contributed to teamwork, with: a) their project planning skills and b) a theory-orientation.

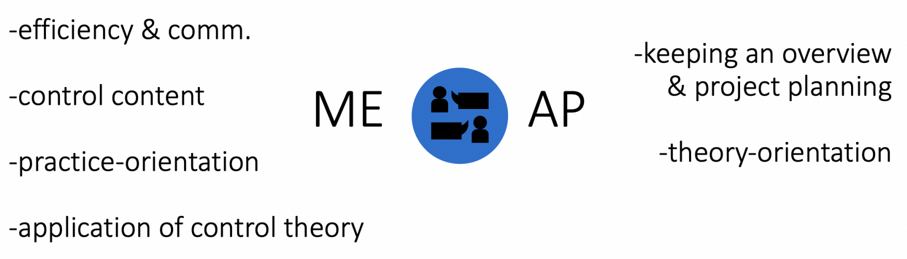

Figure 1. Disciplinary aspects

The second part of the findings showed, as outlined on Figure 2, how the AP and ME students interacted. It is revealed that the interaction of the disciplinary aspects was most evident through: a) division of tasks with leading student(s), b) working in mini-teams, and c) group discussions. Results evidence that this different type of interactions were all found to be useful for students' collaboration in designing their solutions.

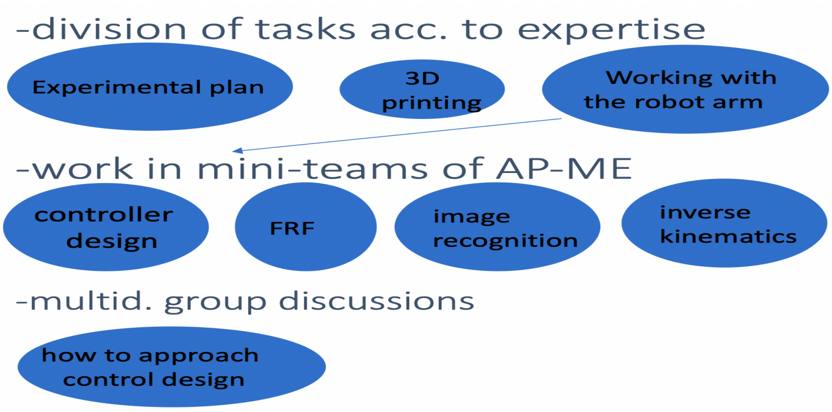

Figure 2. Interactions in the team

3.2.Perceived Usefulness of the CBL Course

Results revealed that the students perceived the course as useful for their professional and personal development with regards to four main aspects: a) involvement of a stakeholder (n = 10), b) hands-on nature (n = 10), and c) professional qualities (n = 11). Figure 3 illustrates the results with more detail.

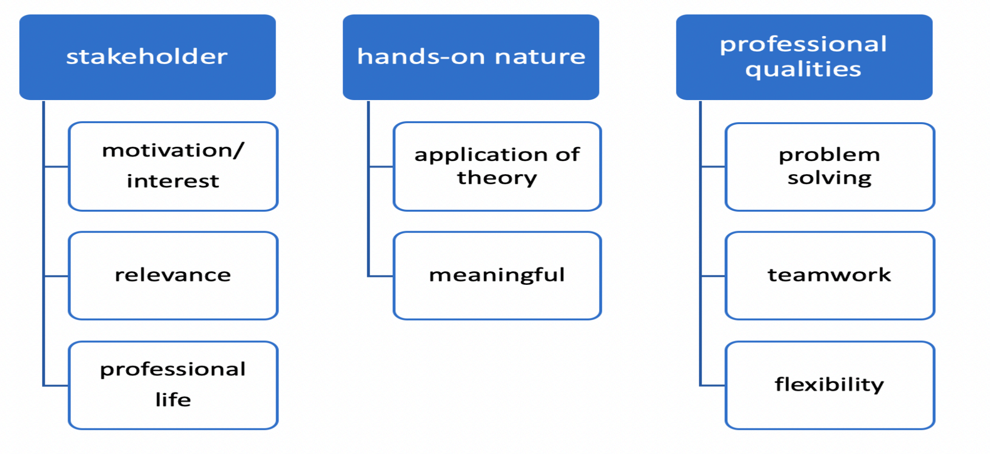

Figure 3. Perceived usefulness for students

The students commonly reported that involvement of a stakeholder in the course caused them fell more motivated towards the course and that interaction with the stakeholder, specifically, lectures by the stakeholder, field trip to the company space, and getting feedback from the stakeholder made the course more interesting. Many student responses focused on gaining relevance and a recognition of professional life, especially on customers, actual cases, and seeing a robot set-up in its real-life context. A selected student quotation is: "…with the increasing automation that the company showed us that they get more and more customers and play a more and more important role in the economy."

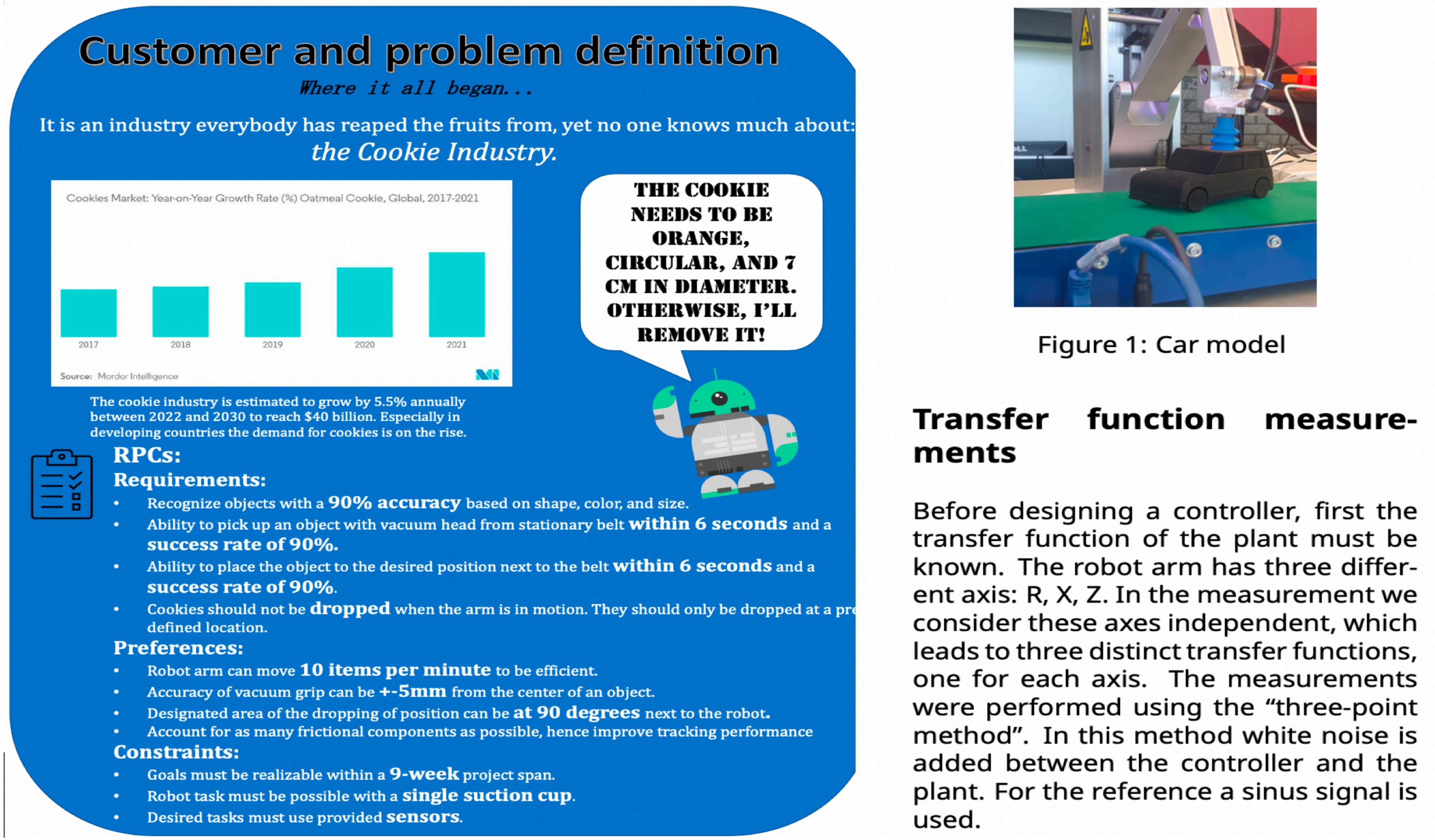

Figure 1. Selected sections of team posters

To continue, the students persistently mentioned the usefulness of a hands-on nature of the course, in terms of providing the opportunity to apply content knowledge and thus making the content more relevant. Two student quotations to illustrate this were: "…seeing the theory applied, it was nice to work on the physical thing" and "so working with the machines and understanding the systems and control theories….my most important key take away." The professional qualities that the students recognized as a useful contribution of the course were problem-solving, teamwork and flexibility. For the third aspect, the students appreciated the flexibility in terms of the freedom given in formulating the problem they wanted to work on. Students highlighted the usefulness of managing the time and their methods in line with their emerging needs.

5.Conclusion and Implications

The close inspection of the boundary processes was performed through collecting data from multiple sources; interviews with students of the two multidisciplinary teams, observations of team meetings, and reflective student journals. It is found very positive that the students of both teams were responsive to the expertise of AP and ME disciplinary communities, and they were able to reflect this expertise in construction of their solutions. It appears that students tried to first understand each other's' disciplinary expertise and strengths. This was followed by making use of expertise to get the necessary benefit from both disciplines in the project. It is encouraging that the two multidisciplinary student teams, while paying attention to the AP and ME expertise, were able to formulate problems with different focuses. For one team, the hypothetical customer was a micro-sized car company in cookie industry and for the second team, the customer was a small-sized car manufacturer.

The results also revealed that the CBL course was perceived as a useful experience for the students in terms of their professional development and preparation for future work-life. Our results suggest designing CBL courses with multidisciplinary teamwork of ME and AP students, paying attention to, including a stakeholder, organizing a field trip to the company site, involving the stakeholder in providing feedback.

Dissemination

Our findings will be disseminated through:

- a presentation at the EARLI Annual Conference in Greece, August 22-26, 2023,
- an article in a peer-reviewed journal, and
- an oral presentation at TU/e, organized by 4TU CEE, December 8th, 2022.