Studying mathematics students' learning experiences in Challenge-based education

STUDYING MATHEMATICS STUDENTS' LEARNING EXPERIENCES IN CHALLENGE-BASED EDUCATION

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ABSTRACT

This paper is of methodological nature. We present the empirical research methodology of a study that focuses on student learning experiences, in particular of mathematics students in an innovative learning environment, such as Challenge-based Education (CBE) at a Dutch university of technology. In this study, we present the case study of CBE in an innovative mathematics course on modelling, the mathematics "Modelling Week". We draw attention to the methodology used to study this modelling course, where we investigated students' learning experiences in a monodisciplinary CBE-oriented master course. We explain the design of the study and the associated data collection strategies regarding students' use of resources (Schematic Representation of Resource system- SRRS) and their learning processes. In the poster presentation, we will show selected results that come from the different

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instruments to help us understand student learning experiences in innovative/CBE related mathematics courses.

1 INTRODUCTION

An increasing number of universities of technology are attempting to adopt challenge-based education (CBE- we use the term to include approaches to teaching and learning). In CBE students work on authentic and real-world focused engineering tasks, generally in multidisciplinary teams, with technology-enhanced learning and multi-stakeholder collaboration [1]. In this educational approach, students learn how to create connections between real-world problems and engineering concepts, principles, and methods. This paper addresses the issue of CBE learning experiences, which Malmqvist et al., identify as [1]:

> "A challenge-based learning experience is a learning experience where the learning takes place through the identification, analysis and design of a solution to a sociotechnical problem. The learning experience is typically multidisciplinary, takes place in an international context and aims to find a collaboratively developed solution, which is environmentally, socially and economically sustainable."

We hold that essential characteristics of CBE can also be applied in monodisciplinary courses, for example in mathematics, where the application of advanced knowledge in a multidisciplinary setting is not straightforward for students. In such a context, we seek to grasp and understand the students' learning experiences in an innovative first year master course in mathematics: the Modelling Week.

In this paper, our aim is to present the methodology used to produce and manage the data in this course so as to account for the way students perceive their learning experiences while orchestrating different resources.

2 THEORETICAL FRAMEWORK

2.1 Challenge-Based Education (CBE)

Challenge-based education is a student-centered educational approach that arises from the concern to prepare engineering students for the new challenges of this century and aims to contribute to the solution of societal problems through collaboration between industry and universities. This type of effective collaboration and hands-on experience is characterized by encouraging students to work with peers/tutors, teachers/instructors, and experts to develop in-depth knowledge and skills on various topics.

2.2 Lens of Resources

In our research we link the development of students' knowledge and skills, during the solution of a problem in the context of CBE, to the use of different types of resources. Thus, we draw on the instrumental approach [2] to observe both how different resources influence students' practice and understanding, and how they modify and adapt them according to their own needs. We follow the categories of resources outlined by Pepin and Kock [3].

3 THE STUDY

This ongoing study uses a case study approach, to investigate and develop a deeper understanding of students' learning experiences in several courses in the curriculum of an Applied Mathematics program (Bachelor and Master) in a university of technology in the Netherlands. One of these courses is the Modelling Week.

3.1 Modelling week

The Modelling Week is part of a mandatory course (Professional Portfolio) in the Applied Mathematics master program on professional skills development. During one week, first year master's students work in groups on realistic problems posed by company/research institute representatives (the "problem owners"). The main outcome of this process is students' interpreting and proposing a solution and recommendations for companies via formulating a mathematical model of the given problem and applying mathematical methods in their solutions. Our study has taken place during the Modelling Week of November 2021. Before the modelling week started, two different activities took place. First, a "Kick-off" lecture was given by the course organizers in order to give relevant information regarding the modelling week process and the creation of the student teams related to their interest areas. Eight teams (6-8 students) were created, four of which agreed to volunteerly participate in our research. Next, a team building workshop ("Lego workshop") was organized with the intention of helping students to get to know their teammates and to learn about team dynamics. Following these events, the Modelling Week started for a period of one week (all day, Monday to Friday). On the first day , problem owners presented the problems for the first time and students were allowed to discuss the details with the problem owners, ask questions for clarification and also request for resources. During the week, students worked as teams to find a feasible and effective solution to the problem. They were guided and supported by university supervisors and problem owners, who also provided feedback on their work. The Modelling Week was concluded on Friday afternoon with the presentations of each team sharing their results. For the majority of students, Modelling Week was the first time they worked on a realistic mathematics problem, posed by an external stakeholder.

3.2 Data Collection strategy

In table 1 (below) we present the data collection strategies used to investigate students' learning experiences in the modelling week.

Table 1. Data collection instruments of the modelling week

Participants	Data Collection Strategy
Students	Exit Cards, Interviews, Observations, Schematic Representation of Resource System-SRRS [4], Survey
Supervisors (Applied Mathematics)	Interviews and Observations
Problem owners	Interviews and Observations

In our poster presentation, our main focus is on demonstrating how the instruments would allow us to analyze student learning experiences [5].

4 PRELIMINARY RESULTS

In terms of results, we present below the different instruments and in which ways they helped us to investigate student learning experiences:

1) With the help of the exit cards, at the end of three data points during the modelling week (Monday- Wednesday- Friday), we were able to get 'snapshots' of students' views regarding their learnings, their feelings towards the achievement of their goal up to that time, their best liked activity, and problems they encountered. This helped us to trace a trajectory of their learning development throughout the week.
2) We made daily observations of students' team work session and interactions with their supervisors and problem owners. We made field notes and took photos (e.g. of student whiteboard notes, calculations, screenshots of software used, schemes). This gave us information about their conversations, the concepts they used, the guidance they received and about their ways of progressing in solving their problem. The observations also showed how ideas from the resources used by the students reappeared in their work-in-progress.
3) The interviews with both the supervisor (university teachers from the Applied Mathematics department) and problem owner helped us to get a better understanding of how their expectations and experiences developed in terms their roles (e.g., from instructor to coach). The interviews also helped us to triangulate the observations of students' learning experiences in class.
4) The student interviews provided us insights into what and how the students perceived and learned in this challenge-based learning environment. The interviews helped us to interpret students' SRRS, so that we obtained an overview of the resources students used (material, digital, social/human), the support they received, different phases and tasks they experienced in the process of solving their challenge/problem, and the important decision making moments in their learning paths.

Together these different kinds of data provided us with a rich picture of students' learning experiences. For example, they helped us understand the role of the resources provided to and found by the students in the teams' work towards developing prototype solutions to the challenges. Moreover, the data gave insights into the characteristics of the problems (posed by the problem owners), as well as their affordances and constraints; the mathematical problems students encountered and how they sought help and support for solving them; the critical incidents and breakthroughs during a 'pressurised' week; the roles students assigned to different participants of the group; the different roles of the problem owner and mathematics tutor, and the alignment and nature of their feedbacks. We will share further explanations and examples during the poster presentation.

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