2023-10-10

Congruence And Friction Between Teachers' Intentions And Students' Perceptions Of CBL Courses

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CONGRUENCE AND FRICTION BETWEEN TEACHERS' INTENTIONS AND STUDENTS' PERCEPTIONS OF CBL COURSES

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Conference Key Areas*: Innovative Teaching and Learning Methods; Fostering Engineering Education Research*
Keywords*: Challenge-Based Learning, Educational Innovation, Teacher, Student, Learning Environment*

ABSTRACT

Challenge-Based Learning (CBL) has become specifically popular in higher engineering education as it embraces authentic, active, and interdisciplinary learning that requires students' self-direction and collaborative decision-making. The CBL compass (van den Beemt et al. 2023) has been widely applied to capture the variety of educational innovations under the CBL label regarding their vision, teaching and learning, and support. As the tool only captures the teachers' intentions and goals, the question remains whether discrepancies occur with student perceptions of the CBL learning environment that may cause friction.

Therefore, this research project explored these discrepancies more thoroughly with teachers and students from CBL courses at four technical universities across Europe.

First, to understand the commonalities and differences between the courses, all courses were mapped with the CBL compass. Analyses of the outcomes showed that the courses varied regarding their implementation of the 36 indicators of CBL represented by the tool – most strongly regarding collaboration with internal and external stakeholders, assessment, and aspects of learning technologies, facilities, and support.

In the next step, we applied the student version of the CBL compass to understand student perception of these indicators and capture differences with teachers' intentions. The results mostly show a high agreement between teachers' intentions and students' perceptions. Friction arises in indicators regarding the complexity of the challenge, the involvement of external stakeholders, and the assessment. The results do not only help our understanding of student learning gains and experiences in CBL but may feed back into teachers' CBL design processes.

1 INTRODUCTION

1.1 Challenge-Based Learning

Challenge-Based Learning (CBL) has explicitly become popular in higher engineering education (see Gallagher and Savage 2020; Doulougeri et al. 2021 for reviews) as it responds to calls for a more modern higher education that prepares students for the reality of later (professional) life in an increasingly complex and volatile world. One of these early calls suggested creating modern teaching and learning environments that use "representative authentic, real-life contexts that have personal meaning for the learners, and offer opportunities for distributed and cooperative learning through social interaction." (Dochy et al. 2003, 534).

Accordingly, CBL embraces authentic, active, and interdisciplinary learning that requires students' self-direction and collaborative decision-making. In the "absence of predefined study, content or challenge" (Gallagher and Savage 2020, 3), students learn "through identification, analysis, and collaborative design of a sustainable and responsive solution to a sociotechnical problem of which both the problem and outcomes are open. CBL at least involves (1) open-ended problems from real-world practice that require working in interdisciplinary teams, (2) entrepreneurial acting and design thinking, (3) combining disciplines, and (4) linking curricular and extracurricular activities. CBL deepens disciplinary knowledge and stimulates 21st-century skills such as self-awareness, self-leadership, teamwork, and an entrepreneurial mindset." (van den Beemt et al. 2020, 62). The phrasing of this definition already indicates that CBL implementation can vary considerably between contexts, depending on specific aims attached to this educational concept in the respective context.

1.2 CBL implementation

In order to capture the commonalities and differences of (possible) CBL implementations and show that the definition of the CBL educational approach may accommodate a large variety of set-ups, van den Beemt and colleagues (2023) developed the so-called CBL compass tool. With this instrument, CBL course designs can be examined based on three categories of dimensions (i.e., vision, teaching, and learning, support) and 36 indicators connected to 10 dimensions (e.g., the extent to which CBL experiments employ real-life open-ended challenges, refer to global themes, and involve stakeholders, aim at educating T-shaped engineers, employ self-directed learning, assessment, teaching, collaborative learning, interdisciplinarity, and learning technologies). Overall, the compass comprises 36 indicators representing the three dimensions and capturing the extent of their implementation.

1.3 Student perceptions of CBL implementation

The emphasis that the CBL educational approach places on student responsibility for their learning and teachers adopting a new role of learning facilitator and coach also leads to a demand for more vital collaboration between teachers and learners. This collaboration, however, naturally requires congruence of both parties' perceptions and interpretation of the learning environment, processes, and goals (e.g., Entwistle and Twait 1990; Vermunt and Verloop 1999). Könings and colleagues (2014) argued that “congruence between teachers’ and students’ perceptions of a learning environment is of central importance for an optimal teaching–learning process.” (p. 13) and incongruence, also called “friction” (Vermunt and Verloop 1999), may negatively affect student self-efficacy, intrinsic interest, commitment, and productivity. Using the *Inventory of Perceived Study Environment Extended* (IPSEE), Könings and colleagues (2014) found that “the majority of students experience substantial differences to their teachers’ perceptions” (p. 17). Specifically, students with the least shared perceptions with teachers reported more motivational and affective problems and less constructivist conceptions of learning, consequently performing worse than other students (p. 27).

While Könings and colleagues have not focused on CBL in higher education but in secondary education, the findings are relevant for CBL research and practice. The course design and implementation of CBL courses are the results of a design process the teacher goes through. Given that CBL is a student-led approach, with students being the central agents in CBL courses, their perceptions of CBL design characteristics are more relevant, and mismatches between teachers' intentions and students' perceptions of the course may cause even more substantial friction in the teaching and learning process.

1.4 Research Questions

Consequently, this research project explored these discrepancies in more detail with teachers and students from different CBL courses at various European technical universities.

Research Questions were:

1) How do teachers (intend to) implement the CBL courses?
2) How do students perceive the implementation of the CBL courses?
3) Do students view…
    a. differ from teachers’ intentions? And
    b. vary among students of the same course?

2 METHODOLOGY

2.1 Procedure and instruments

This research was approved by the collaborating universities' institutional review boards. In a first step, to understand the commonalities and differences of the courses, CBL courses that were part of the EuroTeQ Collider (see 2.2) at four different universities were mapped with the CBL compass (van den Beemt et al. 2023). In order to do so, interviews with the responsible teachers of each course took place right at the beginning of the course, during which the respective course was rated on each of the above-described indicators of the CBL compass tool using a 4-point Likert scale. The comparison of teachers' intention and students' perception focuses on indicators describing the extent CBL courses use real-life and open-ended challenges ("theoretical/abstract" to "real-life"), refer to themes ("no focus" to "full focus"), stimulating interdisciplinary teamwork ("not implemented" to "fully implemented") and the assessment during CBL ("imbalanced" to "fully balanced") as well as involving stakeholders ("no collaboration" to "full collaboration"). Furthermore, general information about the course implementation was collected (e.g., student numbers, course schedule, and set-up).

In order to capture student perceptions of the same courses, students are surveyed with the *student compass*. This tool has an analogous setup to the CBL compass. However, it has been adapted to the student's perspective, has recently been developed at Eindhoven University of Technology, and relevant indicators for answering the research questions were chosen. In a standardized questionnaire, students also rated the implementation of the indicators described above on a 4-point Likert scale. Data collection was scheduled in the middle of the course (depending on the respective timeframe) to ensure students had already gained ample experience to rate the indicators of the compass. Data collection took place between April and June 2023.

2.2 Sample

Teachers and students from CBL courses at four technical universities across Europe were invited to participate in this research. Courses varied in the number of coaches, participating students, timeframe, etc. The duration of the CBL courses varied from an intensive one-week course (University 1 – course 1) to eight-week courses (University 3 and 4 – courses 3 and 4) and a longer sixteen-week course (University 2 – course 2). All courses were open to different study levels and study programs. As the courses were part of the EuroTeQ Collider, a joint European CBL format, the courses shared comparable learning goals and an overarching theme for the challenges.

Due to the varying implementation status of courses, student response rates differed per course. Table 1 provides an overview of student samples per course.

Table 1. Student samples per course

	# students	gender			Study level			Field of study				
		m	*f*	*d/na*	Bachelor	Master	PhD	E	I	B	S	O
Course 1	13	3	9	1	10	2	-	5	6	-	-	5
Course 2	6	2	6	-	-	5	1	-	3	-	1	1
Course 3	9	8	1	-	4	5	-	6	2	1	2	-
Course 4	27	19	7	-	-	26	8	8	1	11	6	7

Notes. Field of study: E = Engineering, I = Informatics and computer science, B = Business and Economics, S = Social Science, O = Other. The selection of more than one study program was possible.

3 RESULTS

3.1 Teachers' intentions for CBL courses

Unanimously, teachers indicated that the challenges students worked on in their courses were real-life/authentic, open-ended, complex, and interdisciplinary, focusing on transforming business as usual and creating societal impact (see Table 2).

Regarding the last indicator of the *Vision* dimension of the CBL compass, the variance between courses could be identified with teachers reporting varying degrees of challenge owners and stakeholder involvement: some involving external challenge owners (e.g., from industry, government, or culture) and stakeholders, others only working with internal experts).

Also, the teachers' ratings reflect the variety in the implementation of the assessment. While a balance between product and process are stated for course 1 and 3, teachers responsible for course 2 and 4 described the implementation as somewhat balanced.

Regarding the last dimension of the CBL compass, namely the *Facilities and Support* available to teachers, courses showed a large variety. While all teachers indicated that adequate spaces were available for their courses, this was only sometimes true for the required materials and tools. Support structures for course design, pedagogical support, and developing coaching skills were also perceived to be available to varying extents (fully available at one university to unavailable at other universities).

3.2 Students' perceptions of CBL courses

Summarizing the descriptive results presented in table 2, students who participated in the CBL courses emphasized the interdisciplinarity of the challenges and, accordingly, a need for interdisciplinary knowledge from different subjects for their teamwork. Besides this, the challenge was perceived by students to support both individual and teamwork and as authentic by focusing on real-life problems.

Regarding assessment, students reported that there was a balance between the assessment of product and process as well as formative and summative assessment.

Differences in student responses could be found regarding the perceived (long-term) societal impact and the involvement of external stakeholders as challenge owners (e.g., course 2: $M = 2.50$, $SD = 1.05$; course 4: $M = 3.69$; $SD = .55$).

When focusing on the variance between responses of students of the same course, especially for the CBL course at University 2 (course 2), a higher variance could be found in how students rated the authenticity of the challenge ($M = 3.50$; $SD =.123$). For course 3, the balance between individual and team learning during the assessment also showed a higher variance ($M = 2.67$; $SD = 1.23$). Further results can be found in table 2.

Differences in students' perceptions, even those attending the same course, may arise from them working in smaller groups on different challenges within and between the courses.

Table 2. Comparison of teachers' intentions and students' perceptions of CBL courses

Indicator	**Course 1**			**Course 2**			**Course 3**			**Course 4**		
	Teacher	Students		Teacher	Students		Teacher	Students		Teacher	Students	
		M	SD		M	SD		M	SD		M	SD
Real-life and open-ended challenges												
Real-life/ Authenticity	4	3.15	.81	3	3.50	1.23	4	3.56	.53	4	3.73	.67
Open-endedness	4	3.00	1.08	3	3.67	.52	4	3.76	.50	4	3.46	.58
complexity	4	2.77	.83	4	2.50	1.00	4	3.56	.53	4	3.31	.84
Interdisciplinarity	4	3.08	.76	3	3.67	.52	4	3.33	.71	3	3.62	.50
Global themes												
Long-term societal impact	4	3.00	1.00	2	3.50	.55	3	3.56	.73	4	3.62	.57
Collaboration with stakeholders												
Challenge-owner	4	2.97	1.04	3	2.50	1.05	3	3.67	.50	3	3.69	.55
External stakeholders	4	2.77	.60	2	3.33	.82	3	3.22	.67	3	3.50	.51
Assessment - Balance												
Product - process	4	3.23	.60	2	3.17	.41	3	3.11	.33	2	3.42	.50
Individual - team	4	3.08	.76	3	3.33	.52	3	2.67	1.23	3	3.42	.64
Formative - summative	4	3.00	.58	3	3.00	.00	4	3.33	.87	2	3.50	.51
Interdisciplinarity												
Interdisciplinary teamwork	4	3.38	.65	3	3.17	.41	4	3.33	.87	3	3.58	.50
Combinations of individual and teamwork	4	3.33	.63	3	3.50	.55	4	3.44	.53	3	3.65	.49
Notes. Teachers Compass: Min. 1, Max 4; Students Compass: Min. 1; Max 4 (1=strongly disagree; 2=disagree; 3=agree; 4=strongly agree)												

3.3 Congruence and friction

Generally, congruence between students' and teachers' perceptions of implementing the CBL courses is relatively high. Based on the results described above, congruence could be identified in teachers' and students' evaluations that the courses use real-life open-ended challenges that require interdisciplinary knowledge and collaboration.

For courses 1 and 2, friction arises concerning the complexity of the challenge. In addition, for course 2, students rated the long-term societal impact higher than teachers. Also, students from courses 2 and 3 show higher agreement for the balance of product and process, individual and team learning, and formative and summative assessment than expressed by interviewed teachers. Also, the balance between formative and summative assessment is rated higher by students in course 4.

4 DISCUSSION AND OUTLOOK

Results from the teacher interviews showed that when implementing the CBL courses, the focus was on the complex, authentic, real-life challenges and the interdisciplinary nature of the challenge and cooperation. Lower scores are reported for assessment, especially for courses 2 and 4 (Research question 1). Students' evaluation of the learning environment also emphasized the implementation of the characteristics mentioned above but showed lower scores for collaboration with external stakeholders and the complexity of the challenge for courses 1 and 2 (Research question 2). We can only hypothesize that this may arise from difficulties in implementing the course and the availability of stakeholders and experts during the work process. In future research, this could be followed up by conducting retrospective evaluation interviews with the respective teachers.

From the high convergence of the student and teacher ratings in the CBL-Compass tool, it can be deduced that both perceive the learning environment and the implementation of the CBL courses in a comparable way (Research question 3), which according to the findings of Könings and colleagues (2014), will benefit student motivation, engagement, and performance in these courses.

Future research will further focus on student learning in CBL courses, trying to understand what type of students are attracted by such courses and whether these students are more open to such new educational approaches and, thus, more perceptive of teachers' intentions. Also, the relationship between the indicators and student engagement and motivation will be researched.

Practical implications include reflecting on collaboration with external stakeholders and transparent communication on the complexity of the challenge and assessment between students and faculty. Furthermore, insights into student learning outcomes in differently designed CBL courses may help the development of the CBL educational approach at different technical universities across Europe, course implementation, and, above all, educational collaboration.

5 ACKNOWLEDGEMENTS

The authors would like to acknowledge the efforts of teachers and students of the courses involved and thank them for making time to contribute to this research.

REFERENCES

Dochy, Filip, Mien Segers, Piet van den Bossche, and David Gijbels. 2003. "Effects of problem-based learning: a meta-analysis." *Learning and Instruction* 13: 533-568. https://doi.org/10.1016/S0959-4752(02)00025-7.

Doulougeri, Karolina, Jan D Vermunt, Gunter Bombaerts, Michael Bots, and Rick de Lange. 2021. “Defining key components of challenge-based learning in engineering education: A review study.” 19th Biennial EARLI Conference, online/ Gothenburg, Sweden.

Entwistle, Noel and Tait, Hilary. 1990. “Approaches to learning, evaluations of teaching, and preferences for contrasting academic environments.” *Higher Education* 19: 169–194.

Gallagher, Silvia Elena, and Timothy Savage. 2020. "Challenge-based learning in higher education: an exploratory literature review." *Teaching in Higher Education*: 1-23. https://doi.org/10.1080/13562517.2020.1863354.

Könings, Karen D., Tina Seidel, Saskia Brand-Gruwel, and Jeroen J. G. van Merrienboer. 2014. "Differences between students’ and teachers’ perceptions of education: profiles to describe congruence and friction." *Instructional Science* 42 (1): 11-30. https://doi.org/10.1007/s11251-013-9294-1

Van den Beemt, Antoine, Miles MacLeod, Jan Van der Veen, Anne Van de Ven, Sophie van Baalen, Renate Klaassen, and Mieke Boon. 2020. "Interdisciplinary engineering education: A review of vision, teaching, and support." *Journal of Engineering Education* 109: 508-555. https://doi.org/10.1002/jee.20347.

van den Beemt, Antoine, Gerard van de Watering, and Michael Bots. 2022. "Conceptualising variety in challenge-based learning in higher education: the CBL-compass." *European Journal of Engineering Education* 48 (1): 21-41. https://doi.org/10.1080/03043797.2022.2078181.

Vermunt, Jan D., and Nico Verloop. 1999. "Congruence and friction between learning and teaching." *Learning and Instruction* 9: 257-280.