Choosing challenges in challenge-based courses

Bohm, N.L.; Klaassen, R.G.; den Brok, Perry; van Bueren, Ellen

Publication date
2020

Document Version
Final published version

Published in
Proceedings SEFI 48th Annual Conference

Citation (APA)
Bohm, N. L., Klaassen, R. G., den Brok, P., & van Bueren, E. (2020). Choosing challenges in challenge-based courses. In J. van der Veen, N. van Hattem-Janssen, H-M. Järvinen, T. de Laet, & I. ten Dam (Eds.), *Proceedings SEFI 48th Annual Conference: Engaging Engineering Education Conference* (pp. 93-103)

CHOOSING CHALLENGES IN CHALLENGE-BASED COURSES

NL Bohm
Delft University of Technology
Delft, The Netherlands

RG Klaassen
Delft University of Technology
Delft, The Netherlands

PJ den Brok
Wageningen University & Research
Wageningen, The Netherlands

EM van Bueren
Delft University of Technology
Delft, The Netherlands

Conference Key Areas: *Challenge based education, Maker projects / Interdisciplinary education*

Keywords: *challenge-based learning, learning ecosystems, motivation, decision making, student-centred approach*

ABSTRACT

Challenge-based learning (CBL) is increasingly on the higher education agenda. In many universities of technology in the Netherlands, CBL is being implemented in engineering education programmes to prepare students to work on authentic, complex, societal challenges, provided by partners from outside of the university. Making societal impact is an important driver the introduction of CBL, however, on a more pedagogical level, little is known about the motivational aspects of student learning in these challenge-based transdisciplinary courses.

In CBL, self-regulation has a prominent role. In many instances, students are asked to make motivated decisions about their development trajectory within the CBL process. One of the first decisions students have to make in these type of learning configurations is what challenge they will work on. The structure of CBL courses often involves several partners that all present their own challenge to the students. Students then have to opt for one of these challenges during the course. In this research, we aimed to get a more detailed understanding of what students consider to be important reasons to choose a particular challenge at the start of a CBL course.

In this research, we investigated the argumentation students used in the process of applying for a challenge in two different CBL courses. The results showed five categories of choice arguments: Content of the challenge, challenge characteristics, personal goals, personal background and collaboration. With a better understanding of student argumentation, expectation and motivation in CBL education, we contribute to the further advancement of transdisciplinary engineering education.

1 INTRODUCTION

1.1 The 'challenge' in challenge-based learning

STEM education is one of the most important tools for universities of technology to make impact on society. Not only by sharing the accumulated knowledge in these institutions with new generations of students, but also by enaging the students with the challenges in society. Universities are becoming learning ecosystems, where students engage in collaborations with societal partners that bring STEM education into their own organisations [1]. The complex challenges of today demand new approaches that organisations cannot come up with by themselve. In recent years, challenge-based learning (CBL) has arisen as a pedagogical structure for the collaborations between universities and a varied group of societal partners [2].

CBL makes an explicit connection between education and society and therefore fits the current strategic ambitions of many universities in the Netherlands to focus on impact for society. Central to CBL is the idea of learning evolving around a 'challenge' that connects societal needs to the problem solving attitudes of engineering students. A challenge in this type of education stems from a societal context, is inherently multidisciplinary and requires solutions to be collaboratively developed [3]. Without a doubt is CBL rooted in problem-based learning, where CBL deals with a more specific shape of 'problem' [4].

The exploration and identification of the project within the challenge is a crucial part of the CBL framework in STEM education. Not only does this step in the CBL process explicitly connect students' learning to (potential) professional practice in their future professional careers, it also highlights a student-centred approach [5]. Students to a large extend define within a challenge what their role and contribution to the problem solving process can be, by synthesising different sources of knowledge input, deal with the unknowns and defining the best approach (disciplining interdisciplinarity). They are confronted with the complexity and openness of a societal challenge and learn that there is not one solution. In line with self-determination theory, this is one of the core motivational aspects of CBL, as it offers autonomy, competence and relatedness to students to make their own decisions based on their interests [6].

The student-centred approach in CBL leads to openness and uncertainty on the side of the organisers of the course. Students may select topics that go beyond the expertise of the teachers or it is even unclear which expertises might be involved in looking for a solution. At the same time, CBL courses make use of real-life challenges, which means that public or private partners come into the university to collaborate with students. These partners find it hard to define a challenge, because they do not know what is important for the student learning process. Similarly, teachers look for new approaches to guide students in CBL and are in need of a better understanding of student motivation in this specific context [7].

The body of knowledge around challenge-based learning is growing. There are some studies that focus on the performance effects of challenge-based learning, but more detailed studies on the learning processes of students are lacking. These studies are important to inform and improve the teaching and learning framework of CBL and offer structure to all participants in these type of courses: teachers, partners and students.

1.2 Aim and research questions

In this research, we are interested to add more detail to the studies in CBL so far, by focussing on the first stage of choosing the challenge in the course. We do this by analysis of motivation letters in two different CBL courses at the University of Technology Delft (TU Delft). In these motivation letters, students had to put forward the argument why they wanted to take part in one of the challenges offered in the course. By analysing these arguments, we aim to answer two research questions:

1. What is the nature of the arguments that engineering students use to choose a challenge in a CBL course at the university?

2. What are the most important arguments for students to choose a challenge in a CBL course at the university?

By gaining a more detailed understanding of what drives students in these courses, we offer teachers and partners in these courses tools to navigate the student-centred approach. Additionaly, we aim to contribute to the further development of CBL learning and teaching frameworks in the future.

2 METHODOLOGY

2.1 Two cases

In this study, two cases were selected that fitted the CBL framework:

1. As part of the joint degree master MSc Metropolitan Analysis, Design and Engineering (MADE) by the TU Delft and Wageningen University & Research (WUR), students engage in a ‘Living Lab’ course that evolves around a

challenge arising from the Amsterdam Metropolitan Region. Over 7 months, students work in teams to develop a solution in co-creation with citizens, knowledge institute and private and public partners that fits their challenge and its context.

2. In the Joint Interdisciplinary Project (JIP) at the TU Delft, is a 2nd year elective master course of 10 weeks, open to all second year students before they graduate. The focus is on solving a company case, usually from the R&D department, in interdisciplinary groups and guided by a company coach, an academic coach and a course coach. The team is (depending on the company) partly embedded within the company and stimulated to consult professionals and academic experts to come up with innovative concept solutions in engineering design.

To set out the specifics of these courses next to each other, we use the framework as proposed by Malmqvist and Radberg [3] in their comparative study of challenge-based learning experiences (Table 1).

The two most eminent differences between the courses are, firstly, the backgrounds of the students. Although both courses have a multidisciplinary focus and attract students with different BSc backgrounds, in the Living Lab course students have had a joint first year of their MSc programme, while in JIP students that took part did not know each other and originate from different programmes. Secondly, the Living Lab students were involved in their challenges part-time over 7 months while the JIP students were involved in their challenges full-time over 10 weeks.

Table 1. Table Comparison of Challenge-based Learning Experiences

	JIP	**Living Lab MADE**
Student year	Year 5 (MSc year 2)	Year 5 (MSc year 2)
Learning outcomes	The ability to integrate (high quality scientific and practical technological) knowledge from different disciplines to solve complex problems and asses the impact of of the proposed solutions on society. An important part is the collaboration, communication and reflection on interdisciplinary teamwork and professional and personal development.	After following the Living Lab course, students will be able to design, facilitate and report upon a process of co-creation that aims at the design of an innovative product, relevant in a real-life, urban setting and contributing to enhanced urban sustainability in the Amsterdam Metropolitan Area.
Student backgrounds	Diverse cultural and disciplinary BSc and Master backgrounds. Mostly in Engineering and Science.	Multidisciplinary MSc programme “MADE” / Diverse BSc backgrounds

Taught topics	Focus on Professional skills development. Very brief introductory activities. E.g. on value based innovation, ethics, product design, teamwork, scrum, legal and financial issues.	Co-creation and experimentation in sustainable urban development.
Typical project	Students are asked to envision airtravel of the future. Sustainable energy sources, materials improvements, but also different ways of travelling and demographic/economic developments impact the way the world changes. Therefore it changes the business case of companies offering numerous possible paths for technological or other developments to change airtravel	Students are asked to design an intervention on the festival 'DGTL' that is aiming to become the first 'circular' festival in the world. Students are confronted with the challenges of circularity and think of ways to analyse the problems and design solutions.
Magnitude	15 ECTS	25 ECTS
Perspective	Global engineering topics	Metropolitan region (local)
Content focus	Sustainability, climate resilience, logistics, energy, health, mobility, digitisation, robotics	Mobility / climate resilience / food / circularity / energy / digitisation
Teacher team	Partners, project-dependent (academic) coach and course coordinator.	Partners, project-dependent (academic) coaches and three course coordinators
Students/year (estimated)	50	35

2.2 Motivation letters

In the two CBL cases studied here, motivation letters were used to have students provide an argumentation to choose a specific challenge. In both cases/courses, students chose a top 3 of their favorite challenges and wrote down the arguments of why these challenges fit their learning trajectory.

Looking at motivation letters offers a perspective on student motivation. Undoubtedly, students aim their motivation letters to the context that they are applying for and therefore the letters are written with a certain strategic aim in mind. The assignment to write a motivation letter in itself might activate specific schemata associated with selection procedures. However, the combination of motivation letters

in a complete student cohort can say something about the consideration and expectations that students have at the start of the course. It gives a detailed insight in students' perceptions of the challenges.

2.3 Open coding

The approach to the coding process has been realised as follows. The Living Lab case was used to establish a grounded set of codes through a process of open coding. In the initial grounded method of coding we tried to keep the coding across the two cases the same as much as possible. Where an argument did not fit the existing set of codes, a new code was added to the group.

Different arguments may have been used by one person and were coded accordingly. It means multiple excerpts with different codes may be from the same person. E.g. If in one motivation letter for choice A, I'm enthusiastic for the sustainability aspect and for choice B, logistics are the argument, both of them will be scored as being present for that student.

36 motivation letters were coded for the Living Lab course, resulting in 606 excerpts and the application of 881 codes. 35 motivation letters were coded for the JIP course, resulting in 253 excerpts and the application of 619 codes. The size of the motivation letters varied between 1-3 A4 pages in case of the Living Lab course and 1-2 A4 pages in case of the JIP course. The samples taken from both cases are therefore comparable in size. Cross-validation has not been realised yet.

3 RESULTS

3.1 The nature of arguments

Table 3 shows all arguments found by the process of open coding in both cases and how many times a certain code was used throughout the motivation letters. In total, 47 differently coded choice arguments were found. Between these codes, arguments had commonalities and we distilled five different groups of argumentation:

- **Content of the challenge:** the topics or themes that the challenge evolves around.
- **Challenge characteristics:** the uniqueness of the learning environment, the possibilities for experimentation or the professional environment.
- **Personal goals:** learning new skills, gaining new skills, experiences or career perspectives.
- **Personal background:** usually previous observations/lessons learned in work context, educational context, or in the homecountry context of the students.
- **Collaboration:** working together with groups from other disciplines, working together with different stakeholder groups.

3.2 The importance of arguments

To answer research question 2, we looked at the frequency with which certain arguments appeared in the motivation letters of students. Tables 4 and 5 show the ten most frequently mentioned arguments for each case. Five arguments appeared in both cases with a high frequency: Previous experience (327 times), collaboration different actor groups (121 times), learning new skills (96 times), sustainability (157 times) and societal impact (97 times). In this section, we discuss these choice arguments more elaborately.

Students in the Living Lab course mentioned 'previous experience' more often than any other argument (83 times). In a further investigation of the excerpts in the coding process, we created more specific codes to split this argument up into: BSc experience, existing skills, work experience, elective courses, curriculum courses and extracurricular activities. Students refered mostly (27 times) to BSc experience within these categories. Relating this to self-determintation theory, students show 'competence' based on their previous experiences in similar situations and use this as an argument for why they are capable of engaging with a specific case in their motivation letters [6]. Knowledge on the backgrounds of students, therefore, remains crucial in the selection process of challenges.

Table 2. Ten most frequently mentioned choice arguments in the Living Lab case.

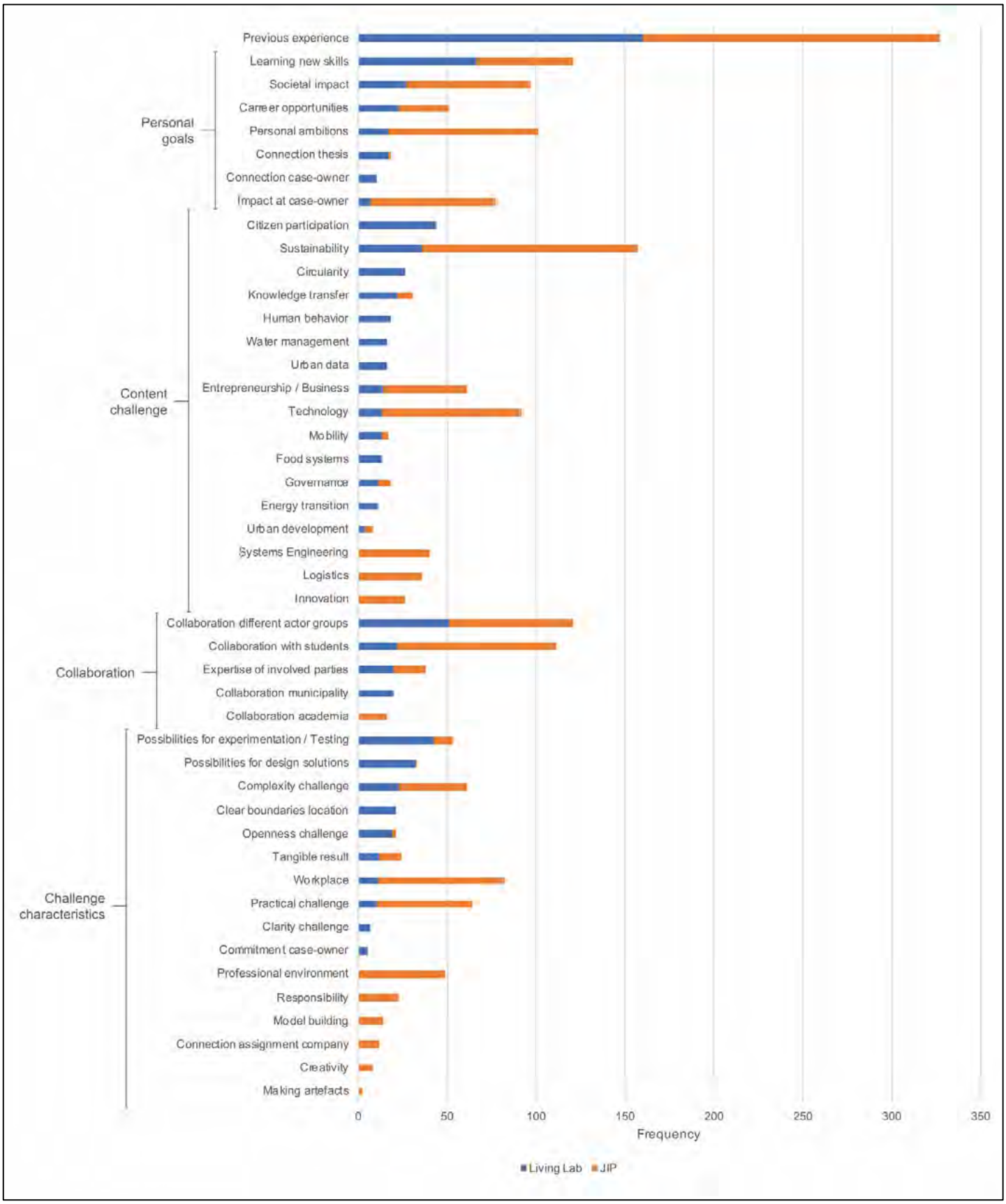
Name	Argument category	Mentions
Previous experience	Personal background	83
Collaboration different actor groups	Collaboration	51
Citizen participation	Content challenge	44
Possibilities for experimentation / Testing	Challenge characteristics	42
Learning new skills	Personal goals	41
Sustainability	Content challenge	36
Possibilities for design solutions	Challenge characteristics	32
Societal impact	Personal goals	27
Circularity	Content challenge	26
Complexity challenge	Challenge characteristics	23

Table 3. Ten most frequently mentioned choice arguments in the JIP case.

Name	Argument category	Mentions
Previous experience	Personal background	167
Sustainability	Content challenge	121
Collaboration with students with a different disciplinary background	Collaboration	89
Personal ambitions	Personal goals	84
Technology	Content challenge	79
Professional environment	Challenge characteristics	71
Collaboration different actor groups	Collaboration	70
Societal impact	Personal goals	70
Impact at case-owner	Personal goals	70
Learning new skills	Personal goals	55

Students want to learn new skills during the course and use this as a choice argument for challenges also. They use this argument roughly as often as ‘societal impact’, the other argument in the ‘personal ambition’ category. Both these choice arguments show the expectations that students have of what they might gain from the challenge. Similarly, many students describe they want to gain experience in ‘collaboration with different actor groups’ (121 times). One of the students describes this as follows: “Considering the different types of stakeholders (e.g. visitors, the municipality, energy providers), I would like to be able to work together with them and to have a role in maintaining this contact between all these different parties.” In both cases, many students describe this need for a broad collaboration to be able to engage in the challenge.

Table 4. Frequency mentions of arguments in both case-studies.



When we look at what particular content the students are attracted by it shows that particularly the argument of sustainability is listed as main argument (157 times) in both cases. Additionally, students frequenly mention technology developments (79 times) and entrepreneurship/business (47 times) in the JIP and to a lesser extent in the Living Lab case. Students in the Living Lab course particularly mention circularity (26 times), and knowledge transfer (22 times), a topic that does not occur among the JIP students. A difference that can be explained by the shared background of the Living Lab students in a learning environment in which circularity is a common topic. Sustainability is often mentioned together with other codes, because students have experience with it, want to make an impact or have an ambition to develop these skills. In JIP sustainability relates in particular to the technological development. Sustainability is a broad notion and in this context needs further investigation to figure out the exact meaning for students in their choice arguments, the result illustrates a shared urgency among students to engage with sustainability challenges.

4 DISCUSSION

4.1 Implications of results and suggestions for further investigation

In this study, we have established an understanding of choice arguments and in this section we want to have a look at what practitioners of CBL can take from this study to apply in their own practice and how researchers can further investigate it. Teachers and partners considering the way to introduce the challenges to the students, could incorporate the five categories in order to connect to what drives students to engage in these courses and to show them different perspectives on the challenge. This study showed that it is not only important to pay attention to the content of the challenge, but also the opportunities it offers for learning new skills, collaboration with different actor groups and the societal impact students could make. Students are looking for what a challenge has to offer to their learning trajectories and for ways to make an impact on society.

Further research should look into this connection between the choice arguments and the learning trajectories of students in the course. CBL offers students the opportunity to make decisions about their own learning trajectories and this study offers insight in the expectations of students. A next question might be if these expectation are met by CBL and to what extend. We realise that a study, such as we have conducted here, that brings all choice arguments of students together to establish one common profile, does not allow to stress the uniqueness of personal arguments and backgrounds that impact decision making. However, students use different categories of choice arguments and it might be possible to discover patterns of decision making. In this study, we showed that certain choice arguments appear in close connection to each other and this needs further investgiation. We expect that it might be possible to distinguish different way of argumentations within this group of

students and this way, we might be able to establish several profiles of choice arguments.

4.2 Conclusions

The main purpose of our study was to gain a more detailed understanding as to what motivates students in their choice for a specific challenge in the context of challenge-based learning. We investigated the choice arguments used in motivation letters of 71 students in two different case-studies and found 5 categories of argumentation that students use: Content of the challenge, challenge characteristics, personal ambition, personal background and collaboration. Several choice arguments play a role in the decision that students make about the challenge simultaneously. At the same time, this study also shows that some arguments are more prevalent in this generation of students. Not only do students look at how they can contribute to a challenge based on previous experiences in education, work and personal life, they also value which skills they might gain in the process. More so do they show a connection to challenges that deal with sustainability and collaboration and that ultimately offer these students a way to make an impact on society. This sheds new light on a generation of students that feels a responsibility to engage with societal challenges and is growing to become the engineers of tomorrow.

REFERENCES

1. Den Brok, P., *Cultivating the growth of life-science graduates: On the role of educational ecosystems*. 2018, Wageningen: Wageningen University & Research.
2. Graham, R., *The Global State of the Art in Engineering Education*. 2018, Massachusetts Institute of Technology (MIT): Cambridge, MA.
3. Malmqvist, J., K.K. Rådberg, and U. Lundqvist. *Comparative analysis of challenge-based learning experiences*. in *Proceedings of the 11th International CDIO Conference, Chengdu University of Information Technology, Chengdu, Sichuan, PR China*. 2015.
4. Clegg, J.R. and K.R. Diller, *Challenge-based instruction promotes students' development of transferable frameworks and confidence for engineering problem solving.* European Journal of Engineering Education, 2019. **44**(3): p. 398-416.
5. Garay-Rondero, C.L., E.R. Calvo, and D.E. Salinas-Navarro, *Experiential learning at Lean-Thinking-Learning Space.* International Journal of Interactive Design and Manufacturing - Ijidem, 2019. **13**(3): p. 1129-1144.
6. Ryan, R.M. and E.L. Deci, *Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being.* American Psychologist, 2000. **55**(1): p. 68-78.
7. Žydžiūnaitė, V., et al. *Independent Learning in Higher Education: What is Important to Students?* in *The Rural Development: Innovations and Sustainability*. 2013. Lithuania: Aleksandras Stulginskis University.