

MAKING GOOD CHALLENGES GREAT – ENGAGING EXTERNAL PARTIES IN CBL ACTIVITIES

Charlotte A. Norrman, Cia Lundvall, Karl Eldebo

Department of management and engineering - Linköping University; Almi East Sweden AB (inGenious); Department of management and engineering - Linköping University

Simon Boiertz, Frans G. Stel

Almi East Sweden AB (inGenious); Department of Change Management and Organizational Behavior - Twente University and Groningen University

ABSTRACT

This paper aims to investigate the challenge-based learning (CBL) approach from the perspective of challenges and challenge providers (CPs), that is, how to successfully collaborate with external CPs and design challenges that work well in university courses and events.

We base this paper on three pillars: literature studies, our own experience teaching CBL in two courses, one at Linköping University and the other at Twente University and interviews with companies and organizations that have participated in the courses as challenge providers.

Regarding the literature studies, we can conclude that the literature on CBL, in general, is extensive. However, it is rather scarce when it comes to studies on how to work with challenges and especially with external CPs in practice; hence, there have not been many theoretical contributions from which to draw. However, those found are in line with our own experience. Through the analysis, we have created a list of learnings that hopefully can benefit organizers of CBL courses and events in their work of creating great challenges.

KEYWORDS

challenge-based learning, experiential learning, enhancement of teaching methods, challenge-based innovation, entrepreneurship education, challenge providers, open innovation, sustainability. Standards: 1, 2, 7, 8, 9, 10

INTRODUCTION

Challenge-based learning (CBL) is a pedagogical approach that has become popular in recent years – both in practice and in the number of research papers on the topic. Challenge-driven innovation is also high up on the agenda of initiatives such as HEInnovate and Horizon 2020 (European Commission, 2015). Also, entrepreneurship is on the agenda, and today more than

a thousand higher education institutions within the EU educate tens of thousands of engineering students in the theory and skill of entrepreneurship (HEInnovate, 2021). The EU has distinguished entrepreneurship competences as one of the eight key competences for lifelong learning (Bacigalupo et al., 2016), defining entrepreneurial education to cover all activities "that seek to prepare people to be responsible, enterprising individuals who have the skills, knowledge and attitudes needed to prepare them to achieve the goals they set for themselves to live a fulfilled life" (Erkkilä, K. 2000, p 229).

In CBL, the learning starts with a challenge, often based upon a real-world "wicked problem"¹ and is supplied by an external party – here labelled "challenge provider," and hereafter abbreviated CP. The students must define and decide how to tackle the challenge, what questions to ask to frame its essence and then design and launch some kind of solution. CBL, especially within the ECIU community, is also known to strive for cross-disciplinary teamwork and focus on challenges related to sustainability. The CBL approach could be used both in curricular courses and for shorter and more occasional events.

For CBL to work, three main ingredients are needed: (1) engaged students/participants, (2) teachers/organizers and (3) interesting challenges. To date, the research on CBL has largely been based on hands-on experiences from engaged teachers/organizers and uptakes of opinions from participants in CBL activities (cf. Leijon et al., 2021). A search through the literature on CBL and related learning approaches shows ample evidence of how CBL affects and benefits students in higher education (Kohn Rådberg et al., 2020). When it comes to the role of the teachers and organizers in CBL, we can find at least some advice in the literature – although this is not as well investigated as the student-related aspects of CBL. To remedy the knowledge gap from the teacher/organizer perspective on CBL, we have written a companion paper (Eldebo et al. 2022) that primarily focuses on the teacher/organizer roles in CBL. The third ingredient in CBL is about working with challenges from external challenge providers (from here on, CPs), creating great challenges and ensuring stakeholder engagement. Also, the CBL-related literature is rather scarce in this area – despite the challenges being a crucial part of the pedagogy. The aim of this paper, therefore, is to investigate the CBL approach from the perspective of challenges and CPs, that is, how to successfully collaborate with external CPs and design challenges that work well in university courses and events.

The paper is outlined as follows: Firstly, we review the literature on CBL and build a frame of reference to underpin our analysis. Next, we give a brief description of the methods used in the paper. This is followed by our data and analysis. Finally, we give our conclusions and advice to those who want to engage in CBL and create great challenges.

CHALLENGE-BASED LEARNING – SOME THEORETICAL STARTING POINTS

CBL in General

CBL is a pedagogical approach that has its roots in the evolution of experience-based learning practices that originated more than eighty years ago by John Dewey (1938; 1963) and later were further developed in pedagogical approaches such as problem-based learning (PBL), action learning, adventure education, simulation and gaming (Kolb & Kolb, 2017). At Linköping University, the tradition of PBL has deep roots, especially in the medical education programs,

¹ Wicked problems are those that are loosely formulated and thereby open to reformulation, cf. Coyne, R. (2005)

whereas project-based learning, which probably also could be seen as one in the above-mentioned family, has deep roots in engineering education. CBL has been described by authors such as Malmqvist et al. (2015) as an evolution of PBL, although with the difference that CBL is more open and has a value-driven and entrepreneurial approach to solving societal concerns.

CBL is both applied and defined in various ways, and there seems to be no single and accepted definition or exact way of how it should be run (Gallagher & Savage, 2020). According to Apple (2008), which was out rather early in CBL, it can be described as an engaging and multidisciplinary teaching and learning approach where students work collaboratively and solve authentic problems. Pérez-Sánchez et al. (2020) describe CBL as a pedagogical approach that “actively involves students in real-life, meaningful and context-related situations” (p. 6). According to the literature review of Gallagher & Savage (2020), CBL is characterized by (1) global themes, (2) real-world challenges, (3) collaboration, (4) technology, (5) flexibility, (6) multi-disciplinarity and discipline specificity, (7) creativity and innovation and (8) challenge definition. The issue of multi-disciplinarity is also discussed by Heikkinen & Isomöttönen (2015), who put forward that the teams should be cross-disciplinary. Based on what has been written, we have chosen to define CBL as an experiential learning approach that starts with wicked, open and sustainability-related real-life challenges that students, in cross-disciplinary teams, take on in their own way and develop into innovative and creative solutions that are presented in open forums.

In recent years, CBL has found its way into our education system, not least due to the formation of the ECIU – the European Consortium of Innovative Universities – in 1997, where Linköping University is a member (Gunnarsson & Swartz, 2021). Over the last few years, challenge-based innovation and CBL have been advocated as the main approach within the ECIU, and on their website (www.eciu.org), the following citation can be found: “The core of the ECIU University is the challenge-based approach – a model where learners, teachers and researchers cooperate with business and society to solve real-life challenges.” The ECIU website states that “CBL is a learner-driven method, where learners take ownership of their challenge, define the problems they want to work on, and acquire the necessary knowledge and skills to solve the challenge. Teachers guide and facilitate team culture, help students to manage the tasks and enable students to move towards innovative thinking.” The phases in the ECIU learning cycle are (1) Engage, (2) Investigate and (3) Act. Within the ECIU, sustainability aspects, particularly the focus of Sustainable Development Goal (SDG) 11, titled “sustainable cities and communities,” are put forward as the focus.

CBL has also been related to the CDIO framework used at Linköping University since 2006 (cf. Ouctherlony, 2006). There are several similarities between CBL and CDIO, as shown in the paper by Gunnarsson and Swartz (2021). In this work (ibid), the CDIO framework (Crawley et al., 2007) is used as a template when the authors develop and suggest a framework for education among the ECIU. Also, Kohn-Rådberg et al. (2020) relate the frameworks of CBL and CDIO and find them compatible.

Regarding the benefits of experiential learning approaches such as CBL, the literature is extensive – especially regarding what is in it for the students – and factors such as networking, real-life practice and skills related to technical, managerial and organizational aspects are listed (Gallagher & Savage, 2020). Apple (2008) advocates that CBL enables 21st-century skills and creates active learning and motivation in the classroom. Lackéus (2020) finds that value-creation pedagogy (which is close to CBL) showed the highest development of both entrepreneurial skills and curricular knowledge and skills. In addition, the students' motivation

was high, probably because of the connection to the real-world problems they solved. Among the drawbacks could be mentioned that non-traditional teaching methods could entail insecurity among students, especially as they might lack knowledge of the specific industry or context (Norrman & Hjelm, 2017).

About Didactics in CBL

The didactic competence of the teacher regarding how education is planned and organized is important for the students' learning process, and according to Børte et al. (2020), there has been a change in the teaching practice in higher education toward a more student-centered approach. However, the same authors stress that the pedagogy in itself is still stable, although utilizing new technology. This is even though it is shown (cf. Leong, Singh & Sale, 2016) that the pedagogic competence of the teacher influences the learning among the students.

The palette of teaching methods facilitating student-centered learning within the education system is extensive. Some approaches are mentioned above, and most fall under the label of experiential learning and are hence claimed to be student-centered. According to O'Neill & McMahon (2005), the term “student-centered learning” can be interpreted in many ways. However, one uncommon aspect is that the students are put in the center, and they state that “that knowledge is constructed by students and that the lecturer is a facilitator of learning rather than a presenter of information” (ibid, p. 28). Irrespective of how student-centered learning is applied, it entails requirements of change in the teacher role. For example, in CBL, the students are seen as active searchers for knowledge and skills and the teacher as a facilitator of this process.

This implies that staff working with CBL need skills that exceed the traditional teacher skills; we discuss this more deeply in the paper by Eldebo et al. (2022). As the teacher role is different, the term “teamcher” is suggested (Gunnarsson & Swartz, 2021) as a label. Eldebo et al. (2022) show that the teamcher role includes both the enabling of knowledge and skills and the ability to set the scene for this. They define a teamcher “as any individual that, either on its own or as a part of a team, arranges, leads and supports CBL activities.” (ibid).

About Challenges

As CBL opens academia to real-world wicked problems, the design of the challenges becomes essential. Hauer and Daniels (2008) talk about open-ended group projects (OEGPs). The challenges in OEPGs are so-called open-ended problems or “ill-structured” problems that train students in dealing with similar types of problems they will meet in their upcoming work life. Working with external challenges is also something that is encouraged by the European Commission; see, for example, Hero & Lindfors (2019).

In CBL, the challenges are often labeled so-called “real-life challenges,” which entails that they originate from external parties from trade and industry, the public sector or NGOs – that is, they are not about desktop products. Challenges can be of different types, for example, mini, nano, standard and strategic, and can be defined as situations or calls for action (Gudonienė et al., 2021). The same authors define a challenge “as a situation or activity that creates a sense of urgency and superior action and enables individuals to find sustainable and innovative solutions” (ibid, page 2). A bearing thought is that the challenge just shall challenge the students and make them act. Membrillo-Hernández et al. (2019) stress in their study that “[a] challenge is a real experience with a high level of uncertainty, designed to expose the student to a challenging situation in the real-world environment in order to achieve specific

learning objectives” (p. 1110). This matter of ambiguity forces the students to investigate, contact experts and gain knowledge to come up with a solution. However, ambiguity may also cause frustration. Frustration may also grow from the fact that the students are forced out of their comfort zone and have to engage in areas that are complex or accommodate conditions they do not master. Hence, the students need support from facilitators. According to Membrillo-Hernández et al. (2019), the gains from such situations are that the students mature and grow. The ability to handle what Bennett & Lemoine (2014) name the “VUCA world” (volatility, ambiguity, complexity and uncertainty) also corresponds to what is inherent in the concept of 21-century skills (Kans, 2016).

According to Gudonienė et al. (2021), it is important that the CP creates and describes the challenge. They also stress the importance of tight relations between the CP and the course organizer. This is to “refine the expectations of the challenge provider in order to be able to advise the students in the context of solving the challenge” (ibid, page 15). This is also supported in other studies, such as Membrillo-Hernández et al. (2019), who point out the importance of the organizers making sure that the challenge fits the learning goals of the course or event. They expressed this as follows: “the learning modules were designed to achieve the goals of both the company and the school. The challenges brought forth issues such as ethical dilemmas, valorization, design planning, scientific methodology and recycling options of solid waste products” (ibid, page 1103).

Regarding the size of the CPs, different approaches have been tested. Membrillo-Hernández et al. (2019) used large world-leading companies that participated with several coworkers as so-called “training partners.” Heikkinen & Isomöttönen (2015), on the other hand, focused their work on the collaboration between the university and SMEs with the aim to improve regional collaboration and knowledge transfer. They found that although the challenge was working well, the industry partners had limited resources when it came to engagement. Challenges might also stem from societal challenges like the SDGs from non-profit organizations.

There are several reasons why external actors engage in university courses as challenge providers. One reason is societal change, and ever since the Brundtland Report concretized “sustainability” in 1987 (World Commission on Environment and Development), companies have been increasingly aware of the paradigm shifts needed to avoid a natural catastrophe, and at the same time, enable continuous development of society (Steffen et al., 2015). The drivers for private companies to engage in sustainability for the larger world are debated. On the one hand, the management literature has long argued that companies need to look for long-term sustainable business in a volatile and uncertain world (Burke, 1985). But to take the step to actually heed the more political question of, for example, the Paris Agreement (2015), the corporation has to move outside the boundaries of its organization and take a more holistic view of its stakeholders and surrounding society (Lozano, 2011). That is, it must head for “open innovation” processes, a concept coined by Henry Chesbrough (2003), defined as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively” (Chesbrough, 2011, p. 1). The concept has been largely accepted by researchers as a method of dealing with the world of innovation pacing at an always accelerating speed. Private companies have to deal with new ways of innovation flows, and the role of the Innovation Manager is no longer only facing internal processes and people but also dealing with different partners for innovation supply and how the incumbent firms position themselves in an innovation ecosystem (Jones et al., 2016). Collaboration with universities and their students is a part of this.

Lozano (2011) points out several drivers for companies to engage in innovation for sustainability with universities and students. Brand recognition is one of them; finding new employees is another apparent reason. But other internal factors also play a role, like ethics and personal drivers in management, the need for business intelligence on new technology and the development of new, more sustainable products. Developing products or changing the supporting processes in product manufacturing could be key to finding great challenges for students. According to the BS 8001:2017 Framework for implementing the principles of the circular economy in organisations – guide, the largest environmental impact is found in the designing of products. Product development is thereby an important way for a company to become sustainable in economic terms. As companies start to design for sustainability, it has also been noted that they tend to expand the horizon from a purely technical focus to a more holistic socio-technical scope (Ceschin & Gaziulusoy, 2016). Companies simply need a strategy for innovation that is not internal anymore (Enkel & Sagmeister, 2020; Teece, 2007).

METHOD

Two projects underpin this study, an internal pedagogical development project (PUG) financed by Linköping University and the EU ERASMUS+ project S4S, Scale Up for Sustainability, where the partnership consists of two universities, one academic institute and seven companies (see also Acknowledgements). In our work with CBL in these projects, we recognized that the areas where most efforts were needed were the role of teachers and how to work with challenge providers. To deal with this, we decided to write two papers – one on each topic. An implication is that parts of the frame of reference and parts of the data are shared with Eldebo et al. (2022).

This paper is based on three main sources of information. Firstly, we have reviewed the literature on experiential learning in general and CBL in particular, focusing on challenges and CPs. We have also regarded different frameworks for learning, such as CDIO and the development within ECIU. Secondly, we have used our own experience in arranging and running CBL courses and activities over several years. This research approach is described by Lewin (1946) as action research and by Hayano (1979) as autoethnographics. If we go back to the roots, Dewey (1938; 1963), who advocated experience as the “means and goal of education,” utilizing our own practice and reflecting on it to move forward is in practice what CBL is about. Thirdly, we have interviewed CPs that have participated in our courses.

As the empirical study objects for this, two courses have been investigated. The first is ECIU inGenious – Cross Disciplinary Project Course (799G52) – which comprises 8 ECTS credits and runs once or twice a year at Linköping university in cooperation with Almi East Sweden AB since 2014; in total, 15 rounds have been given thus far. In total, about 279 students have worked with 68 challenges from external CPs from the start and up to now. Second is the Fujifilm challenge, which comprises 4 ECTS credits and has been given annually since 2016 (in total, 5 rounds) and has since then engaged 222 students at the bachelor’s and master’s levels and one challenge provider – however, it is well represented regarding staff as, in total, 29 individuals have been involved and 47 new ideas have been generated so far. Taken together, this implies that our empirical base covers several years and contains more than 500 students and more than 115 ideas/challenges treated.

CHALLENGE-BASED LEARNING - OUR EXPERIENCE

The inGenious Course

The course has been given under different names since 2014 and primarily as a cross-disciplinary course for students at Linköping University. Since 2020, we have a multicultural element as the course has been open for ECIU and, thereby, more exchange students and ECIU students have joined it. The course has always been student-centered, but since 2018 we began to label this as challenge-based learning.

The inGenious course is a single-subject course that requires 90 approved credits to be admitted to the course. The course is both interdisciplinary and multidisciplinary. Following the definition of Heikkinen & Isomöttönen (2015), it can be labeled as cross-disciplinary. Each project group consists of four to six students from different faculties and programs. The challenges come from trade and industry, the public sector and non-profit organizations, mainly from the region around Linköping University. Besides the idea- and development process, the course focuses greatly on teamwork and group processes. Other focus areas are communication and especially pitch technique. Also, ethics, by means of how to think responsibly during an innovation process, are part of the course.

Linköping University (LiU) and Almi East Sweden AB (a regional co-owned and co-financed subsidiary in the state-owned Almi Företagspartner Group) have joined together in a partnership regarding the inGenious course. Almi East Sweden AB takes the responsibility of establishing contacts with trade and industry and supplying the course with challenges, while the university is responsible for the academic part of the course. What is unique with the inGenious course at LiU is that the students have opportunity to capitalise on what they develop connected to the challenge with which they are provided. To become a CP in the course is free of charge. After the course is finished, the CP has a first right-of-refusal to the results for a symbolic payment (maximum about 5000 euros). If not, the students are free to exploit the results themselves with support from both Almi East Sweden AB and the innovation support facilities at LiU. When choosing CPs, much work is invested in getting the presumptive CPs to understand what is required from them and what they can expect from their engagement. They are informed that the students are not consultants that will work on a specific path pointed out by the CP but instead are to make their own thing.

Challenges that result in solutions that are regarded as innovative and with commercial potential or in another way can be utilized in society are in most cases challenges formulated to create a bigger value from a sustainability and/or societal perspective. In addition, we have experienced that these challenges to a large extent, come from CPs who have been involved in the students and are interested in their idea development processes. Less "successful" challenges are commonly those that are narrowly formulated and formulated in a relatively targeted manner. These challenges can be perceived more as "consulting." Our experience is that it is important to strive to get challenges from CPs with the right approach, that is, those who are curious about the students and appreciate that the project group works independently and without influence and understand that the solutions may be something else than what was initially thought or expected. We have learned the importance of carefully clarifying what is expected of a CP and what they can expect (and not expect) from the students who take on their challenge. We also explain that this is not about a consulting assignment and that we want the students to reformulate the challenge so it suits the project team and their competencies. They must develop a solution they believe in themselves.

Furthermore, it is important to maintain contact with the participating CPs, for example, keep them updated on activities they are expected to participate in, make sure that they take the time to answer students' questions and provide feedback, for example, at pitching occasions. We have seen that participating companies get essential input to their business through interaction with the students. The CPs get new ideas and (innovative) solutions and new knowledge, not least in the area of sustainability. The CPs can follow the students throughout an entire course and see their skills and abilities, which often leads to increased interest in the students – as master's thesis workers or future employees. Through Almi East Sweden AB, the CPs can contact students even after completing the course.

As an example of a challenge used in the course, the one from Ligna Energy Ltd. can be given. Ligna is a green tech start-up company that collaborates with the Laboratory of Organic Electronics (LiU) to develop disruptive technology and products for large-scale electrical energy storage. The Ligna Energy battery solution is relatively bulky since the energy density in Wh/kg is a factor of 10 less than competing technologies. Cheap materials enable cost efficiency, but customers must accept higher weight and volume in the storage system. The challenge given was formulated as follows: Find ways to manage bulkiness for the Ligna Energy battery customers – to minimize the impact of this product drawback. This may be done in many ways, and we are open to adaptations of the shape and arrangement of the battery packs.

The Fujifilm challenge

Fujifilm Ltd, known for its photographic and imaging activities, focuses increasingly on new markets with substantial, sustainable impact: bioengineering, energy and environment and healthcare and medicines. Fujifilm has a mission to improve the quality of life for people worldwide. To achieve this mission, it is eager to receive fresh new ideas from students. The Fujifilm Future Challenge (FFC) program started in 2016. Student teams co-create with Fujifilm's open innovation hub to develop new sustainable business models with Fujifilm's technologies. In a 10-week program, it has developed 47 new business ideas. In total, 222 bachelor's and master's students and 40 staff of 5 academic partners participated in the program, while Fujifilm involved 29 R&D staff. The international interdisciplinary teams produce two video pitches and two business model canvasses and then pitch their business solution to a professional jury. They develop and test business models based on real customer feedback. Apart from an educational program, the challenge serves research purposes concerning the impact of entrepreneurial and innovative traits (Innovator's DNA) on new venture performance.

Creative solving of complex wicked sustainability problems is a vital element of the FFC program. Therefore, teams identify, explore and define a real problem into an initial business model-in-four: value proposition (what is the "pain" and "gain"), customers (to whom and how to sell), how to implement (main activities and partners) and the monetary aspects (categories of income and expenses). In the second half of the FFC program, participants validate their initial business models.

The FFC focuses on creativity, innovation and acting like entrepreneurs. In the FFC, Fujifilm is an external CP and an enabler: R&D managers are available for discussions with the student teams and provide technological and market context. As real entrepreneurs, the student teams are expected to take the initiative in the discussions. The teams develop and test new business ideas based on the vast array of core technologies of Fujifilm. Specialists at Fujifilm are their technological sparring partners, while teachers coach the teams weekly and monitor their progress.

In the FFC, participants are highly committed (score 8.4 on a scale of 1-10). They highly value the creativity and team components (8.0 and 8.1, respectively). These ratings are higher than the perceived complexity. With the help of some creativity tools, weekly coaching sessions and technological support, students can find and test possible solutions to wicked sustainability problems. Afterward, due to their real experience with a high-tech company, students feel more confident in innovative entrepreneurship. As examples of learnings from the Fujifilm challenge could be mentioned that commitment and team processes are the strongest predictors of new venture performance. Furthermore, the format could be upscaled and digitalized; a larger scale adds to the program's impact.

Among the weaknesses in the Fujifilm collaboration is the risk of being too dependent on only one company, giving the students less freedom. Also, the fact that the setup is time-consuming needs to be mentioned (cf. Fichter et al. 2020).

In this course, Fujifilm is the CP. Fujifilm is the world's largest photographic and imaging company. However, it is less well known that it is a leading innovator in the fields of bioengineering, energy and environment, medicine and membranes. The company states it has a mission to improve the quality of life for people worldwide and that input from students hence are of importance.

The challenge was formulated as follows: "To develop and test new product ideas based on the technologies of Fujifilm. You will have access to specialists at Fujifilm and will be coached to develop ideas, spot opportunities and test how your ideas in the market in a great international company. Learn about creativity, innovation and acting like an entrepreneur!"

Some voices from challenge providers that have participated in our courses

inGenious CP1 is a rather large company within the paper and tissue industry. Its reason to engage as a CP was to get closer to the university. It was also interested in getting new ideas in connection to a new sustainable material that it had obtained. It appreciated that the students actively volunteered for its challenge, as this was seen as a guarantee that the students were curious and engaged and therefore could be expected to do their best. The CP chose to buy back what the students had developed and paid about 2500 euros for their solution. They report that they gained new and deepened knowledge in, for them, important sustainability-related issues.

inGenious CP2 is an SME that creates software for digital displays. The company sought a solution that could make it possible to use digital displays without connecting to the mains and indoors where daylight is missing. The CP had wished that the student group would have continued to develop the solution and then formed a joint venture with the company, but since the students did not want to continue, the solution became that the idea was repurchased for the sum of about 1000 euros.

inGenious CP3 is an SME within the workwear industry. It sought solutions to develop internet sales. The students were a good way toward developing such a solution when they learned that another group in another course was working on a similar idea. For that reason, they decided to abandon their initial solution and instead go for another one – far away from the initial challenge. Their new solution was instead focused on recycling worn-out workwear and was broadened to meet upcoming regulations on recycling, and hence focused on the needs of the entire workwear industry. The CP did not repurchase the solution, but there is still a

much learn from this case. The CP said that it wanted to cooperate with the university and regarded it as a societal responsibility to participate in joint projects. It also said that the cooperation keeps up creativity and that the university contacts help with recruiting. Finally, it noted that challenges too close to the firm's core business are problematic for several reasons: "If the challenge is too closely linked to the company's existing core business, difficulties may arise for both the company and students. The company can, for example, find it difficult to share sensitive information with students, and students may find it difficult to create something new because the company has already thought through many possible scenarios and solutions."

Regarding the Fujifilm challenge, Fichter et al. (2020) show that business partners joined in as CPs because they wanted to acquire new knowledge, new markets and new ideas. One of their biggest challenges reported was the ability to stay open to the questions they got from the students – that is, to not immediately jump towards the solution but to stay more open for their questions. In the past, Fujifilm was confronted with the quick erosion of its analog photo business. Therefore, it considers it vital to explore and develop completely new markets. To operationalize its new mission (improve the quality of life for people worldwide in bioengineering, energy and environment, medicine and membranes markets), it uses the Fujifilm Future Challenge as a "window to the world," that is, to get an impression about the needs and interests of new generations. Participating students and R&D officers of Fujifilm discuss and develop to co-create new business opportunities. Every edition of the Fujifilm Future challenge has different focus points, depending on the needs of the company. Regarding long-term effects, the impact on the business level was limited and more inspirational in character. Fujifilm also reported that its corporate image toward students, as future employees, was strengthened. It also benefited from the contributions regarding the sustainability goals (SDGs). Some citations are worth mentioning from the evaluation by Fichter et al (2020). These are:

"A module like this becomes very dependent on the actors involved, and adding a business partner to a module can be challenging. Therefore, it is important that participating actors are motivated and engaged" (p. 66).

"Regarding weaknesses or challenges: the strength of having a close collaboration with only one company can also be a weakness since the module becomes very dependent on that specific company. The strength mentioned by the teachers, that is, that competition between student teams brings motivation, is somewhat contradicted by the business partner, who noticed that sometimes a lack of competition faces the potential risk of student teams being too relaxed." (p. 67)

DISCUSSION

Different perspectives

An optimal challenge is built from different perspectives. In this paper, we have identified four main perspectives: the didactical perspective, the student perspective, the external stakeholder/CP perspective and the university outreach perspective.

The didactical perspective

From a didactic perspective, a challenge must be formulated in a way that gives the students good chances to reach the learning goals of the course. It also needs to challenge the students

and give them skills that make them attractive in the labor market. Hence, the planning of a course needs to start from the questions of what, why and how (Børte, Nesje & Lillejord, 2020) we should think, act and organize in order to strengthen the learning process. When working with external, real-life challenges, academia and the surrounding ecosystem of companies, organizations and public bodies meet and interact. This is to be seen as an opportunity for the students, and it adds relevance and context to the courses as they are being prepared for future employment (cf Norrman et al., 2014). Working with challenges in cross-disciplinary teams trains students in their ability to work in groups, communicate with other professionals and stakeholders, think critically and be responsible when working with innovation. These are the skills required to navigate a future landscape characterized by volatility, uncertainty, complexity and ambiguity (cf. Bennet and Lemoine, 2014).

The student perspective

From a student perspective, it is good if the challenge enables opportunities to get real-life experience (Gallagher & Savage, 2020; Apple, 2008) and build a network, both on the social and professional levels. As an example, this could be about learning to know individuals or companies that could provide opportunities for a master's thesis or even employment. It is also good if the course or event helps the students to develop and grow as individuals. Such skills are pointed out in previous studies (cf Pérez-Sánchez et al., 2020) and ought to be one of the most important outcomes of cross-disciplinary teamwork with external stakeholders, as such work forces the students to cooperate, negotiate and communicate. This also seems to hold true in our study.

The stakeholder/challenge provider perspective

The size of the challenge provider does not seem to be a crucial factor. As shown by Membrillo-Hernández et al. (2019), it is possible to work with large firms – this was also the case in the FujiFilm challenge. On the other hand, the study by Heikkinen & Isomöttönen (2015) shows that SMEs are suitable CPs, which is also proven in the inGenious course. Instead of size, it seems to be about engagement and the CPs' ability to let the course team develop their idea from their own prerequisites.

From a CP perspective, it is the desire that the challenge leads to new input or even a new innovative solution that the stakeholder can benefit from (cf. Lozano 2011). Firms and organizations that hand in projects to the inGenious course are aware that their participation allows them to buy back what the students have developed. They are also made aware that participation as a CP requires engagement.

The reasons why a CP chooses to engage in CBL can vary depending on strategy, size of the company and internal needs, according to the literature (cf. Heikkinen & Isomöttönen, 2015; Jones et al., 2016; Lozano, 2011; Membrillo-Hernández et al., 2019). In our interviews, the external CPs' attitude toward the university and their reason to engage vary accordingly. Some, and especially those that lack formal contacts, participate due to curiosity and regard being a CP as a way to approach the university. Others are interested in meeting researchers. Some, who already have good contacts, engage for other reasons, for example, to market themselves and come into contact with students or to get new eyes on problems.

For CBL to work, it is our experience that the commitment of the external parties is crucial, as also stated by Membrillo-Hernández et al. (2019). The most desirable reason for participation

is that CPs engage to acquire new eyes, insights, ideas and solutions, irrespective of whether it will lead to commercialisation.

The university outreach perspective

It is also beneficial for universities to engage in CBL and work with external actors, not least due because the universities are demanded to reach out to society (Heikkinen & Isomöttönen, 2015). Hence, engagement in CBL can be seen as a way to reach out to the surrounding ecosystem of industry and public organizations. In other words, it is about networking and the diffusion of knowledge.

To summarize our analysis, we have created a checklist of aspects to benefit organizers of CBL courses in their work to make great challenges.

A great challenge ...

- ought to be wicked and structured as a “big idea” that is open and able to be broken down into a graspable take – however, still big enough to constitute a challenge in terms of requirements on the student team when it comes to engagement, problematization and investigations in order to form a solution.
- entails that the solution is not obvious to the CP nor to the students. The challenge should not be able to be solved immediately, but instead require engagement, thorough investigation and hopefully also lead to some kind of action.
- must be a real-life challenge but could be formulated by the teacher or the students themselves, but cooperation with external stakeholders such as industry partners, governmental bodies or organizations is desirable as this adds real-life relevance to the work.
- should be formulated in a way that it becomes possible for a cross-disciplinary team of students to take it on in an open innovation process, irrespective of their backgrounds, respectively. That means that all students in the group must be able to latch on to the challenge in their own way. Hence, if two groups take on the same challenge, they will most probably come up with different problem definitions and solutions.
- utilizes the team and its complementing skills, as dynamic teams work more efficiently (Wheelan, 1999) and seem to go further in finding (innovative) solutions.
- originates from a CP or stakeholder that is curious and interested in keeping in contact with the students and likes to interact and cooperate with them. It is desirable that the CP follows the students' process as a speaking partner and provides them with feedback – but without trying to steer them into a certain track. To ensure this, aligned expectations and clear communication between “teamchairs” and CPs are crucial. If this relation fails, “teamchairs” must always be on the students' side and be prepared to encourage a Plan B.
- has a pedagogic purpose for the students to acquire both knowledge and skills that they can benefit from in future work life. It also entails opportunities to build a network – both with fellow students and external parties.
- enables the open innovation process and is directed toward sustainable and responsible innovation. Furthermore, it should strive to lead to practice – by means that it leads to utilization and implementation. Within the ECIU, this is incorporated into the ACT phase and following CDIO, it is about the ability to enter the “operation” phase and realize the idea.
- has as its goal to lead to a solution that is of interest not only to the CP but also to a wider group of stakeholders and interested parties, for example, on the regional,

national and even international levels. This opens up opportunities for cooperation and open innovation.

Challenges that are too narrow or too focused on a certain technology risk becoming hard for all students in a group to latch onto. To remedy this, we recommend that challenges are formulated in cooperation between the team/center behind the course and the CP. In working with challenges, we should strive to avoid:

- regarding the students as consultants that should follow a presupposed track and leverage a solution that is determined from the beginning, and hence are more interested in getting a solution to commercialize than being curious about the students' knowledge and what new input this could lead to. To remedy this, we recommend the "team/center" team makes sure that the CPs are aware of the prerequisites so that their expectations become aligned with the purpose of the CBL activity.
- unrealistic expectations in terms of output and time spent. Therefore, discussing what the CP can and cannot expect from its engagement in a CBL course is vital for a lasting relationship. In addition, the communication patterns between participating students and company officials should be clear.
- abandoning the students and the CP making themselves unavailable for contact. To remedy this, we recommend the "team/center" team makes sure that the CPs are aware of the prerequisites and what is required to act as a CP in the actual situation.
- leveraging challenges that are too close to the organization's core business, as this may entail problems with secrecy issues and thereby also the supply of adequate information. Furthermore, there is an immediate risk that the organization will focus on a presupposed solution rather than an open mind for any solution.

CONCLUSIONS

This paper aimed to investigate the CBL approach from the perspective of challenges and CPs, that is, how to successfully collaborate with external CPs and design challenges that work well in university courses and events.

We define CBL as an experiential learning approach that starts with wicked, open and sustainability-related real-life challenges that students, in multidisciplinary teams, take on in their own way and develop into innovative and creative solutions that are presented in open forums. Furthermore, we have developed a checklist of what to consider when working with external CPs in CBL courses. We have reached the following conclusions:

Firstly, we have realized that the literature is rather scarce when it comes to the practice of working with challenges, especially regarding the collaboration with external challenge providers, and hence there have not been many theoretical contributions to draw upon in our analysis. However, those found are in line with our own experience.

Secondly, we have observed that the difficulties lie in the creation and design of challenges that are wide enough to create a certain amount of VUCA and allow for an open innovation process, but at the same time aim at pushing the students to engage in the challenge and investigate and act upon the challenge. Challenges that foster open innovation are, even if tough to handle, often seen as more inclusive as they enable students with different backgrounds to latch onto them. Furthermore, such challenges open the students to find a solution rather than *the* solution.

Thirdly, we have found that the collaboration inherent in CBL is a win-win situation for all parties concerned. Challenge providers get new perspectives and contacts with both students and university staff. Students gain real-life experience and important skills that future employers will demand, plus contacts and a network. For universities, it is a way to reach out to and interact with the surrounding ecosystem; it implies significant work and can sometimes force them outside of their comfort zones, but it also allows them to expand their business network and help their students develop and grow.

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REFERENCES

Apple (2008) Challenge-based learning – Take action and make difference. <https://www.apple.com/ca/education/docs/Apple-ChallengedBasedLearning.pdf>

Bacigalupo, M., Kampylis, P., Punie, Y. and Van Den Brande, L. (2016) *EntreComp: The Entrepreneurship Competence Framework*. EUR 27939 EN. Luxembourg (Luxembourg): Publications Office of the European Union. JRC101581

Bennett, N., & Lemoine, G. J. (2014). What a difference a word makes: Understanding threats to performance in a VUCA world. *Business Horizons*, 57(3), 311-317.

Burke, W. W. (1985). *Leaders: The strategies for taking charge*, by Warren Bennis and Burt Nanus. New York: Harper & Row, 1985, 244 pp., \$19.95. *Human Resource Management*, 24(4), 503–508. <https://doi.org/10.1002/hrm.3930240409>

BS 8001:2017 Framework for implementing the principles of the circular economy in organisations – guide (<https://www.thenbs.com/PublicationIndex/documents/details?Pub=BSI&DocID=317511>)

Børte, K., Nesje, K., & Lillejord, S. (2020). Barriers to student active learning in higher education. *Teaching in Higher Education*, 1-19.

Ceschin, F., & Gaziulusoy, I. (2016). Evolution of design for sustainability: From product design to design for system innovations and transitions. *Design Studies*, 47, 118–163. <https://doi.org/10.1016/j.destud.2016.09.002>

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business School Press.

Chesbrough, H. W. (2011). *Open innovation: The new imperative for creating and profiting from technology* (Nachdr.). Harvard Business School Press.

Proceedings of the 18th International CDIO Conference, hosted by Reykjavik University, Reykjavik Iceland, June 13-15, 2022.

Crawley, E., Malmqvist, J., Ostlund, S., Brodeur, D., & Edstrom, K. (2007). Rethinking engineering education. *The CDIO Approach*, 302, 60-62.

Coyne, R. (2005). Wicked problems revisited. *Design studies*, 26(1), 5-17.

Dewey, J. (1938; 1963). Experience and education, The Kappa, Delta, Pi Lecture Series, Macmillan Publishing company: New York

Eldebo, K., Lundvall, C., Norrman, C., and Larsson, M. How to Make Good Teachers Great in Challenge-based Learning, 18th CDIO Conference June 13-15 2022, Reykjavik, Iceland.

Enkel, E., & Sagmeister, V. (2020). External corporate venturing modes as new way to develop dynamic capabilities. *Technovation*, 96–97, 102128. <https://doi.org/10.1016/j.technovation.2020.102128>

European Commission (2015) Entrepreneurship Education: A road to success. Ref. Ares (2015)338751 - 28/01/2015

Erkkilä, K. (2000). Entrepreneurial education: mapping the debates in the United States, the United Kingdom and Finland. Taylor & Francis.

Fichter, K., Hurrelmann, K., Seela, A., Hjelm, O., Larsson, M., Sundberg, C., Wisdom, K. & Stel, F. (2020). S4S Report on evaluating leading approaches and tools in collaborative green venturing (Work Package 2). Oldenburg, Linköping and Zuidlaren

Gallagher, S. E., & Savage, T. (2020). Challenge-based learning in higher education: an exploratory literature review. *Teaching in Higher Education*, 1-23.

Gudonienė, D., Paulauskaitė-Tarasevičienė, A., Daunorienė, A., & Sukackė, V. (2021). A Case Study on Emerging Learning Pathways in SDG-Focused Engineering Studies through Applying CBL. *Sustainability*, 13(15), 8495.

Gunnarsson, S. & Swartz, M. "Applying The Cdio Framework When Developing The Eciu University" Proceedings of the 17th International CDIO Conference, hosted online by Chulalongkorn University & Rajamangala University of Technology Thanyaburi, Bangkok, Thailand, June 21-23, 2021.

Hauer, A., & Daniels, M. (2008). A Learning Theory Perspective on Running Open Ended Group Projects (OEGPs). Proc. Tenth Australasian Computing Education Conference (ACE2008), Wollongong, Australia, 78, 8.

Hayano, D. M. 1979. Auto-ethnography: Paradigms, problems, and prospects. *Human Organization*, 38, 113-120.

HEInnovate (2021, 01, 10) An initiative of the European Commission's DG Education and Culture in partnership with the OECD. <https://heinnovate.eu>

Heikkinen, J., & Isomöttönen, V. (2015). Learning mechanisms in multidisciplinary teamwork with real customers and open-ended problems. *European Journal of Engineering Education*, 40(6), 653-670.

Hero, L. M., & Lindfors, E. (2019). Students' learning experience in a multidisciplinary innovation project. *Education+ Training*.

Jones, J. N., Cope, J., & Kintz, A. (2016). Peering into the Future of Innovation Management: As the world changes, innovation professionals consider what the future holds for innovation and innovation

Proceedings of the 18th International CDIO Conference, hosted by Reykjavik University, Reykjavik Iceland, June 13-15, 2022.

management. Research-Technology Management, 59(4), 49–58.
<https://doi.org/10.1080/08956308.2016.1185344>

Kans, M. (2016). What Should We Teach?: A Study of Stakeholders' Preceptions on Curriculum Content. In *12th International CDIO Conference, Enhancing Innovation Competencies through advances in engineering education, Turku, Finland, June 12-16, 2016* (pp. 266-278). Turku University of Applied Sciences.

Kohn Rådberg, K., Lundqvist, U., Malmqvist, J., & Hagvall Svensson, O. (2020). From CDIO to challenge-based learning experiences—expanding student learning as well as societal impact?. *European Journal of Engineering Education*, 45(1), 22-37.

Kolb, A. Y., & Kolb, D. A. (2017). Experiential learning theory as a guide for experiential educators in higher education. *Experiential Learning & Teaching in Higher Education*, 1(1), 7-44.

Lackéus, M. (2020). Comparing the impact of three different experiential approaches to entrepreneurship in education. *International Journal of Entrepreneurial Behavior & Research*, 26(5), 937–971.

Leijon, M., Gudmundsson, P., Staaf, P., & Christersson, C. (2021). Challenge based learning in higher education—A systematic literature review. *Innovations in Education and Teaching International*, 1-10.

Leong, H., Singh, M. N., & Sale, D. (2016). Enhancing teaching skills: a professional development framework for lecturers. In *The 12th International CDIO Conference* (p. 760)

Lewin, K. 1946. Action Research and Minority Problems. *Journal of Social Issues* 2: 34-46.

Lozano, R. (2011). Addressing Stakeholders and Better Contributing to Sustainability through Game Theory. *Journal of Corporate Citizenship*, 2011(43), 45–62.
<https://doi.org/10.9774/GLEAF.4700.2011.au.00004>

Malmqvist, J., Rådberg, K., Lundqvist, U. (2015). From problem-based to challenge-based learning – motives, examples, outcomes and success factors. 2015 11th International CDIO Conference, Chengdu, China

Membrillo-Hernández, J., Ramírez-Cadena, M. J., Martínez-Acosta, M., Cruz-Gómez, E., Muñoz-Díaz, E., & Elizalde, H. (2019). Challenge based learning: the importance of world-leading companies as training partners. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 13(3), 1103-1113.

Norrman, C., Bienkowska, D., Moberg, M., & Frankelius, P. (2014, June). Innovative methods for entrepreneurship and leadership teaching in CDIO-based engineering education. In *Proceedings of the 10th International CDIO Conference, Universitat Politècnica de Catalunya, Barcelona, Spain, June 16* (Vol. 19, p. 2014).

Norrman, C., & Hjelm, O. (2017). CDIO-based entrepreneurship courses as drivers of innovation in industrial segments. In 13th International CDIO Conference, University of Calgary, Calgary, Canada, June 18-22, 2017 (pp. 288-297). University of Calgary.

O'Neill, G., & McMahon, T. (2005). Student-centred learning: What does it mean for students and lecturers.

Ouchterlony, U., A PROJECT FOR THE PROGRAMME OF INFORMATION TECHNOLOGY AT LINKÖPING UNIVERSITY, 2006, 2nd International CDIO conference, Linköping university, Sweden.

Proceedings of the 18th International CDIO Conference, hosted by Reykjavik University, Reykjavik Iceland, June 13-15, 2022.

Pérez-Sánchez, E. O., Chavarro-Miranda, F., & Riano-Cruz, J. D. (2020). Challenge-based learning: A 'entrepreneurship-oriented' teaching experience. *Management in Education*, 0892020620969868.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., de Vries, W., de Wit, C. A., Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B., & Sörlin, S. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, 347(6223), 1259855. <https://doi.org/10.1126/science.1259855>

Teece, D. J. (2007). Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, 28(13), 1319–1350. <https://doi.org/10.1002/smj.640>

Wheelan, S. A. (1999). *Creating effective teams: A guide for members and leaders*. Sage.

World Commission on Environment and Development (Ed.). (1987). *Our common future*. Oxford University Press.

BIOGRAPHICAL INFORMATION

Charlotte Norrman: is an Associate Professor at the Department of Management and Engineering at Linköping University (LiU). Her research focus is innovation and entrepreneurship in early stages ventures, and she also work with regional development. Her teaching is in the area of innovation and entrepreneurship. She has contributed to the CDIO-conference several times and is also engaged within the ECIU community.

Cia Lundvall is a facilitator at Almi East Sweden AB and part-time lecturer at the Department of Management and Engineering at Linköping University. She has previously worked with marketing and taught students in rhetoric and Swedish at Upper Secondary Schools for many years. As a facilitator, she monitors the students' group process, sees that the projects progress and trains the students in pitch technique.

Karl Eldebo is a Lecturer and PhD student at the Division of Environmental Technology and Management at the Department of Management and Engineering at Linköping University. He has taught entrepreneurship and innovation management for five years to engineering students. His research is mainly focused on the dissemination of innovation for a sustainable world.

Simon Boiertz: is a facilitator at Almi East Sweden AB and works also for LiU Student Innovation. He has a background as a rehabilitation specialist and competences within areas such as leadership and facilitating. As a facilitator, he monitors the students' group process, sees that the projects progress and trains the students in pitch technique.

Frans Stel is a managing consultant at Vennebroek Academic Services (VAS), a consultancy, training and coaching company aimed at higher education and a senior research associate at Universities of Twente and Groningen. His research focus is the development of 21st century skills via challenge-based learning games on creative problem-solving, negotiation, cross-cultural collaboration, and alliances. He has presented his work in various conferences, for example, AOM, EURAM, European Conference of Game-Based Learning (ECGBL) and ISPIM.

Corresponding author

Charlotte Norrman
Linköping University
Department of Management and
Engineering.
58183 Linköping
Sweden
charlotte.norrman@liu.se



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