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Case Studies

Academy for DESIGN INNOVATION MANAGEMENT Conference 2019 LONDON, UNITED KINGDOM
19–21 JUNE 2019 Research Perspectives IN THE ERA OF Transformations

Contamination Lab of Turin (CLabTo): how to teach entrepreneurship education to all kinds of university students

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Interest in offering Entrepreneurship Education (EE) to all kinds of university students is increasing. Therefore, universities are increasing the number of entrepreneurship courses intended for students from different fields of study and with different education levels. Through a single case study of the Contamination Lab of Turin (CLabTo), we suggest how EE may be taught to all kinds of university students. We have combined design methods with EE to create a practical-oriented entrepreneurship course which allows students to work in transdisciplinary teams through a learning-by-doing approach on real-life projects. Professors from different departments have been included to create a multidisciplinary environment. We have drawn on programme assessment data, including pre- and post-surveys. Overall, we have found a positive effect of the programme on the students' entrepreneurial skills. However, when the data was broken down according to the students' fields of study and education levels, mixed results emerged.

Keywords: Entrepreneurship education, design thinking, entrepreneurship, design education

Introduction

The European Commission defined a sense of initiative and entrepreneurship as "key competences [..] which all individuals need for personal fulfilment and development, active citizenship, social inclusion and employment" (EC, 2006, pp. 4). Therefore, local, national and international actors (universities, business incubators, foundations, corporations, policy makers) are working together to promote Entrepreneurship Education (EE) for all kinds of university students (Katz, 2008; do Paço et al., 2011; Duval-Couetil, 2013). This is probably due to the fact that EE increases the students' entrepreneurial competencies (e.g., Man and Lau, 2005; Phan and Siegel, 2006; Pittaway and Edwards, 2012; Duval-Couetil, 2013; Shahab et al., 2019), entrepreneurial intention (e.g., Kolvereid & Moen, 1997; Peterman and Kennedy, 2003; Fayolle, 2005; Shahab et al., 2019) and entrepreneurial activities (e.g., Kolvereid & Moen, 1997; Mueller & Goic, 2003; Florin et al., 2007). Moreover, entrepreneurial competencies can be valuable, not only to create start-ups, but also to work in innovate corporations, since they require entrepreneurial mind-sets and pro-active employees. In addition, universities have increased attention towards EE as part of their 'third-mission' (Siegel and Wright, 2015; Birtchnell et al., 2017) in order to foster the entrepreneurial culture of their students and to develop the local entrepreneurial ecosystem. Therefore, there has been a remarkable expansion in the number of programmes devoted to EE (e.g., Katz, 2008; Fretschner and Weber, 2013), in part because students have expressed a desire to participate in EE programmes (Peterman and Kennedy, 2003).

However, despite its popularity, the vagueness of the EE teaching goals (Hoppe, 2016) and its pedagogical approaches (Thursby et al., 2009; Piperopoulos & Dimov 2015; Nabi et al., 2017), there are still some important weaknesses that future research should try to face. For instance, there is a need to create more practical-oriented entrepreneurship courses (Cooper et al., 2004), and the introduction of design thinking into EE may be a solution to this need (Glen et al., 2014). Moreover, the impact of the entrepreneurial abilities of EE students might vary considerably, according to the students' characteristics (Piperopoulos & Dimov, 2015; Maresch et al., 2016) and the content and pedagogy of the entrepreneurship course (Piperopoulos & Dimov, 2015). Most studies on EE (see Nabi et al., 2017 for a recent literature review) have analysed an EE course offered to a specific field of study (e.g., management) and a specific educational level. Therefore, it is not clear how to teach entrepreneurship to students from different backgrounds and with different levels of education (e.g. bachelor and master), since most of the EE literature refers to a single field of study, which is mainly related to business curricula. However, it is important to teach entrepreneurship to students from different backgrounds in order to create multidisciplinary teams, thus fostering an innovative and entrepreneurial mind-set. Colombo and Grilli (2005), for instance, using the human capital theory, suggested that entrepreneurial teams composed of team members from different backgrounds perform better than others. Moreover, if a student works for an innovative company, he/she will probably work in a multidisciplinary team. This suggests that EE in a multidisciplinary environment is also important for students interested in innovation. In fact, several companies make employees from different backgrounds work together as a strategy to deliver innovative products/services. In addition, companies are increasing their open innovation strategies through the creation of different activities, such as corporation incubation programmes (Becker and Gassmann, 2006; Kohler, 2016). For all these reasons, it is important for students to learn how to work in multidisciplinary teams.

This paper, in order to overcome these drawbacks, is aimed at explaining how it is possible to combine design thinking with EE in order to develop a practical-oriented entrepreneurship course. Moreover, we suggest how entrepreneurship may be taught to students from different fields of study and with different educational levels and help them to work in multidisciplinary teams. In order to do so, we have investigated the entrepreneurship activities developed by the Contamination Lab of Turin (CLabTo) in Italy. We decided to analyse CLabTo because it is a recent programme that was funded by the Ministry of Education, University and Research (MIUR) in Italy in 2016, that is aimed at fostering the entrepreneurial and innovative abilities of all kinds of university students. The aim of CLabTo is to enhance the students' specialised expertise and integrate it with new capabilities to face new, uncertain and complex situations in the real world (e.g. solving real-life/entrepreneurial/societal problems) through learning-by-doing. In CLabTo, we combine EE with design thinking, design methods, cognitive processes, techniques and sensibility for solving problems (Glen et al., 2014).

Following the structure of Thursby et al. 2009, we have drawn on programme assessment data. We administered pre- and post-surveys to the participants to assess the barriers and the obstacles to teaching entrepreneurship in a multidisciplinary environment. Out of 62 participants, 56 participants answered both the pre- and post-surveys, thus yielding an effective response rate of 90.3%. In general, we found a positive effect of the programme on the students' entrepreneurial skills. However, when the data were analysed after breaking them down into the students' fields of study and their education level, mixed impacts emerged for the course on students' entrepreneurial skills. Moreover, on the basis of their answers, it emerged that students liked the multidisciplinary environment of CLabTo and the fact that it is based on real cases and a learning-by-doing approach. However, since our sample was only composed of 56 students and a control sample was not available, our analyses can only be considering qualitative.

We contribute to the theory of literature on entrepreneurship by adding our case study to the structure of Thursby et al. (2009) and by explaining how entrepreneurship may be taught to different levels of university students. Moreover, as suggested by Glen et al., (2014), we suggest how design thinking and EE may be merged in order to develop a practical-oriented entrepreneurship programme, thus contributing to the discussion started by Nielsen and Stovang (2015) by creating knowledge about the cross-over of design thinking and EE. Lastly, this study has a practical implication for scholars, teachers and policymakers interested in how to teach entrepreneurship in a multidisciplinary environment.

This section is intended to frame and introduce the relevance of the topic. The next section will focus on the literature review in order to articulate where this new research is located and how it could add new knowledge. The CLabTO programme is introduced in section 3 as a key study to explain how to integrate EE and design thinking. We show the results obtained on the basis of the Clab teaching model in section 4 and the answers received from the pre- and post-surveys, including the overall degree of satisfaction with the programme. A discussion on the results is presented in the fifth section, together with the limits and implications for future research.

Literature review

According to Rae & Carswell (2000), a learning-by-doing programme enhances the development of student's entrepreneurial competencies. In fact, Cope and Watts (2000) explained that individuals learn from experiences and failures. Therefore, it is important for students to test and try their hypotheses through real project-work in order to develop their skills. Moreover, such an activity allows students to work in a real-case project on their own ideas, which can help them and teachers to create a more innovative and experimental environment, in part because students are more enthusiastic about working on their own ideas. In addition, the recent social and technological changes that have taken place blur organisational boundaries and emphasise collaboration (Browder et al., 2019). Therefore, it is important for students to know how to collaborate in a multidisciplinary environment. However, collaborating with people from different backgrounds can be complex, and it requires some experience. It is possible to understand, from the literature, that technical students (from engineering and natural science) lack skills in management, communication and team-based problem solving, all of which are critical for decision making in innovation-related careers (Thursby et al., 2009). Moreover, Thursby et al. (2009) suggested that there is a growing need to address this gap without sacrificing specialised and in-depth technical training. In fact, many critiques of Business school education emphasise the need to overcome the rational analytic approach of such curricula, which have been proved to address the complexity of real-life and entrepreneurial problems in an unsatisfactory manner (Glen et al., 2014; Nielsen and Stovang, 2015; Taatila, 2010; Huber et al., 2016). Furthermore, they suggest introducing practical approaches, such as design thinking, to unlock the potential of entrepreneurial and innovative students to deal with practical cases and active learning, in order to help business students develop design skills and mind-sets. On the other hand, another strand of literature points out the need to introduce EE into the curricula of design schools to increase the ability of design candidates to turn product ideas (concepts) into actions and to develop managerial, economic and strategic thinking skills (Gunes, 2012). In fact, EE is expected to allow designers to develop entrepreneurial skills and mind-sets, in order to create new jobs in the future and to become major drivers of economic growth through creativity and innovation (Gunes, 2012).

In this work, we seek to demonstrate that design thinking should play a fundamental role in EE that is complementary with business education (Glen et al., 2014, Nielsen and Stovang, 2015) for any field of study. The two disciplines should coexist in a practice-base new course that is able to encourage students to participate with a learning-by-doing approach centred on action (Joannisson et al., 1998). Several studies have proved that EE, in order to be efficient, must be practical (e.g., Cooper et al., 2004). Thus, we have used design pedagogy to provide the practical approach and stimulate thinking outside the box for any field of study, that is, not just the managerial or design fields.

The CLabTo programme

Introduction to the Contamination Lab (CLab) programme and to CLabTO

The CLab programme is a nationally funded programme that now counts 22 CLabs in Italy. Each of these CLabs is recognised at a ministerial level (Directorial Decree no. 315 of 29 November 2016). This entrepreneurship programme involves two universities in Turin – the Politecnico di Torino and the University of Turin – in which both technical and humanistic disciplines are taught. The CLabTo programme has the aim of developing the students' skills in running their own businesses, as well as in working in highly innovative contexts, by training them through EE and design methods with entrepreneurial and real-life challenges. The goal of CLabTo is twofold. On the one hand, it has the aim of creating the entrepreneurial intention of students to become entrepreneurs or innovators. On the other hand, it seeks to help students to develop skills (such as problem solving, team working, etc.) that are increasingly being requested by companies that operate in innovation fields by introducing design thinking into EE.

Programmes

CLabTo is a sprint-like challenge-based programme that is directed towards innovation. It combines EE and design thinking by allowing students from various backgrounds to apply them to real challenges in the industrial or academic worlds. It includes three different programmes which have three different intents, durations and expected outcomes.

The intention of Type 1 (CLab Workshop) is to generate new ideas in the form of feasible concepts and it lasts 1 or 2 weeks. Type 2 (CLab Sprint) includes prototyping and it lasts from 2 to 4 weeks. Type 3 (CLab Master) has the goal of validating technical, business performances and IP studies to forward the ideas and the prototypes to a more advanced stage, and it lasts from 3 to 6 months. Each of these 3 programmes is divided into courses (training) and team experience (team working). In other words, the first part involves a discussion between students and professors from different research fields. This first part is aimed at filling the theoretical-methodological and entrepreneurial gaps of the students with diverse curricula and from different backgrounds. The professors teach the students the skills necessary to address specific real-life problems and propose coherent and innovative solutions. Professors from different departments and research fields also increase the multidisciplinary aspect of delivering pedagogy. The second part mostly involves team-based work where the students have to face a complex and unpredictable situation within a multidisciplinary environment within which they have to consider several variables. In the second part, professors, experts from industry and entrepreneurs help students by giving feedback on their team-work as mentors/tutors. This second part is aimed at representing a real case as much as possible. CLabTo engages students in tasks, activities and projects that should enable them to acquire key entrepreneurial skills and competences in a real-life situation (Nielsen and Stovang, 2015).

Structure of the challenges

In this paper, we have analysed two types of challenge since, until now, we have organised only three challenges: two type 1 challenges (CLab Workshop) and one type 2 challenge (CLab Sprint). However, the overall duration of both types was limited to two weeks. The structure of these challenges is described hereafter.

The type 1 programme focuses on generating new ideas and exploring alternative solutions in order to allow the students to think beyond technological push solutions, by considering the centrality of the user they are designing for and thus reframing the needs to which they have to respond with different solutions. This type of challenge leads students to develop concepts that are characterised by a certain degree of technical and economic feasibility. Moreover, the solutions are usually iterated with the relevant stakeholders from the local ecosystem during revisions, meetings and intermediate presentations. The type 2 programme, instead, introduces the production of working prototypes, which are developed in a suitable environment for prototyping activities, the Fablab Torino. The students have the chance to experiment with shape and materials through different technologies (Browder et al., 2019), such as 3D Printing, CNC machining, programming on Arduino and Raspberry Pi shields, and are supported by mentors (Figure 1). During these challenges, the focus is more on the process than on the outcome.

Figure 1: Fablab tutoring

As far as the overall structure of the challenge (both type 1 and 2) is concerned, during the first days, the students are required to build their multidisciplinary teams, an activity that is facilitated by team-building exercises. We relied on a team of researchers from the Department of Psychology of the University of Turin, led by professor Cristina Mosso, to perform this activity, settle disputes and balance skills and competencies.

During the first week, we provided the students with short teachings (1-2 hours) on sustainability, entrepreneurship, design thinking, digital innovation and communication, that is, the mandatory modules of our programme, which were delivered by professors from different departments. In the same week, they were also taught challenge-specific contents by university faculty members (both professors and researchers) and industry mentors (entrepreneurs and experts). The organisation of these classes is dealt with in detail in the result section and the students' feedback is commented on. The second week, in the type 1 programme, the students worked in teams to develop their ideas with the support of tutors and mentors, while in the type 2 programme, they worked in teams to develop both their ideas and a working prototype in the FabLab Torino, and on this occasion they were supported by makers, computer engineers and other tutors. On the last day of the challenges, they performed a 10-minute pitch in which they presented their ideas to an audience that included CLab programme members, university faculty members, industry mentors and members of the university incubators.

The first challenge was a type 1 challenge on the specific topic of electric mobility, in cooperation with Iren S.p.A.[1], and it took place in July 2018. The second was a type 2 challenge on the topic of sustainable food conservation, which took place in November 2018, and the third one (type 1) on the potential impact of new technologies (such as AI) on our future life and jobs, which also involved the Visionary association[2], took place in December 2018.

These specific challenges gave the students the opportunity to test their theoretical knowledge in a practical case in multidisciplinary teams and then learn from the others and through mistakes and feedback from the mentors. Each participant provided his/her knowledge and expertise to a programme where there was room to make mistakes, to test and to experiment. In fact, since there was no exam, the students felt free to make errors and to try. They learned more about the specific topics from the tutors, mentors and professors from both industry and academia. CLabTo in fact collects students who are interested in a topic, whatever background they have, provided they have been enrolled in university. The followed teaching model gives rise to the cognitive difference theorised by Reynolds and Lewis (2017). It includes an enhancement of the difference in perspectives and how students elaborate and process information (knowledge processing), as well as how they think about and engage with new and complex situations (Reynolds and Lewis, 2017).

Opportunities

Although multidisciplinary, collaborative learning projects that inspire entrepreneurship are not unusual, the CLabTo programme is extracurricular and it is intended for students from all fields of study and from different university educational levels who are willing to take on a challenge pertaining to a specific topic. Therefore, CLabTo allows an entrepreneurship programme to be developed for all the enrolled students, albeit outside the university environment, but closely related to it. This is in line with what Thursby et al. (2009) expressed:

> *Introducing entrepreneurship education to graduate programs is challenging because they are typically highly structured and allow little room for courses outside the primary discipline.*

CLabTo was created to solve certain problems (such as credits for different students from different departments, different professors involved in a course), with the intent of being a neutral place where they could conduct experiments. In this way, different types of teaching that could be relevant for EE are now accessible to the various students in a single place. CLabTo adopts teaching methods and space layouts for teaching and team work which stimulate cooperation among the students who work in teams. We witnessed an active role of the participants and a revised the role of the teachers as tutors and facilitators, who were willing to learn from the students and to build the programme with them (Celaschi, 2008). Although this type of approach was originally theorised for design curricula, it should be noted that it is somewhat novel for other types of students who are not used to receiving design pedagogy. On the other hand, students in design schools often discuss and negotiate their ideas with other stakeholders from different fields, but it is not as common for designers to work effectively in transdisciplinary[1] teams, mainly with non-designer students. Combining EE and design thinking, in addition to the previously mentioned characteristics, makes the CLabTo programme different from those that have already been analysed in the literature. This programme includes business and design pedagogies, but it is not intended specifically for business or design students.

According to Yee et al., (2017), the importance of the design process can be summarised as:

1. a cultural catalyst, which promotes both openness and pragmatism;
2. a framework maker, which provides and organises the whole project system (information, spaces, partners, etc.);
3. a humaniser, which encourages empathy in the creative process;
4. a power broker, which tries to break down prejudices and maintain the human-centric focus;
5. a friendly challenger, which encourages an environment of openness and trust and spurs a constructive critique of each-others' work;
6. a technology enabler, which ensures the as fluid as possible transition between physical to digital and the other way around;
7. a community builder, which attracts people (students, mentors, specialists, etc.) with the final goal of enlarging the network of participants to create important impacts.

In addition, another important factor of CLabTo is its focus on sustainability (social, economic and environmental) for all the CLabTo challenges, since there is growing attention on this topic (UN SDGs (2015).

Teaching environment

Since the classroom layouts and University spaces usually dedicated to teaching are unsuitable for these kinds of activities (Nielsen and Stovang, 2015), we provided a physical environment for learning and team work that allows a complete reconfiguration, according to the type of activity that has to be performed. We avoided fixed furniture and opted for wheeled furniture that could be arranged to best satisfy the needs of the students' activities. In this environment, the professors chose the best layout according to the type of lesson, and preferred to sit among the students in circles, or they divided the students into groups for group exercises. Moreover, as mentors, they gave them feedback on their work. In addition, each table was individually cabled and this allowed projection onto a canvas and audio play from any part of the room. This allowed the students and professors to work in a more informal and open environment.

Description of the study population

In this paper, we refer to the study population by reporting data pertaining to all of the participants in the 3 challenges described in the previous section (e-mobility, food conservation and visionary). Overall, from July to

[1] Herein, we refer to transdisciplinary team work, since students from different backgrounds created outputs that are completely new and different from the outputs achieved by means of multidisciplinary cooperation. They integrated their perspectives with a holistic approach that falls outside any disciplinary boundaries.

December 2018, 62 students took part in these 3 challenges and they therefore represent the study population.

The study population was composed of 61% men and 39% women. Of these, 75% were MSc, 25,5% BSc and the remaining students were PhD candidates. It can be noticed, from Figure 2, that 16 students came from humanities, 13 students were engineers, 12 came from management or management engineering, 11 were designers or architects and 10 came from natural sciences. Some of these categories were identified by Thursby et al. (2009) i.e. Engineering, Management and Natural Science, and we added two extra categories, that is, Design&Architecture and Humanities.

This varied and extremely multidisciplinary sample was a good starting point for the creation of 16 heterogeneous teams.

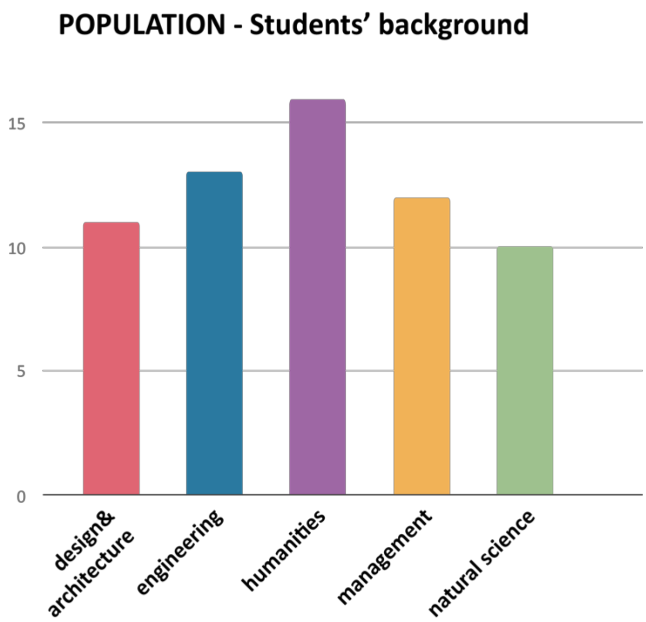

Figure 2: Students' backgrounds divided into categories

The study population of the challenges was generally aged between 20 and 34 years, with an average age of 25 years. The age distribution of the study population showed a peak between 25 and 26 years.

We developed and administered pre- and post-surveys to assess the students' perceptions of their skills or multidisciplinary competencies on entry and exit (Thursby et al., 2009). Data from these surveys allowed us to evaluate the effects of student learning across degree programmes. The assessment goals were both formative and summative, so that the students' feedback and performances could be used to improve the programme (Thursby et al., 2009).

Results

Combining EE with design thinking

As working in innovative sectors and entrepreneurship is increasingly heading towards transdisciplinary collaboration, students will find themselves collaborating with people who have different mind-sets. This EE type of path seems suitable to provide skills that would otherwise not be provided by traditional training. The ability to change their mind-sets in order to communicate effectively and to co-design with people with different curricula will be an essential skill for workers in the coming decades, as indicated by the EU commission (EC, 2006, pp. 4) and by Colombo and Grilli (2005), whether the students decide to start an entrepreneurial path or decide to be employed in stimulating and innovative environments. In fact, even within start-ups when the team is particularly homogeneous, in terms of background and *forma mentis* (in the way to engage with and think about change), this slight cognitive diversity and multidisciplinary reduce their versatility in how to approach a task and their ability to accomplish it (Reynolds and Lewis, 2017). It has been proved that colleagues usually gravitate towards people who think and express themselves in a similar way (like-minded teams) and have limited ability to see things differently (Reynolds and Lewis, 2017).

For this reason, we tracked the composition of the teams during the proposed challenges in order to make sure a certain degree of cognitive diversity and multidisciplinarity was satisfied. Introducing team building in the first two days of the challenge was appropriate to prompt the students to get to know and compare a small number of people before the onset of friendship or bias among the classmates.

The teams so far have been composed of 3 or 4 people with at least 3 different skills. The winning teams of the three challenges were in fact constituted by four students from three different fields of study, which implies that two students for each team were from the same field of study, as is shown below:

1. E-mobility: two students from Humanities, one from Design&Architecture and one from Engineering;
2. Food conservation: two students from Design&Architecture, one from Management and one from Natural Science;
3. Visionary: two students from Natural Science, one from Engineering and one from Management.

However, it should be noted that the students from the same field of study belonged to different courses and had different levels of education.

Challenge-specific results

During the type 1 challenge on e-mobility, the students were asked to provide a feasible solution to multimodal transport that included all-electric vehicles, that is, from car sharing to scooters and bicycles. The students provided 8 interesting possible solutions, and the winning team focused on a solution that benefited from the historic and well-distributed tram network in the city of Turin, suggesting the provision of multifunctional power stations near the existing junctions.

During the type 2 challenge on food conservation, the students hypothesised alternative food preservation methods. In the prototyping phase, they experimented machine learning, voice recognition and shape recognition of food (Figure 3), as well as temperature/humidity recording and automatic correction measures (Figure 4). The winning team demonstrated, with humidity and temperature sensors, the effectiveness of the pot-in-pot system[2], which consists of two clay containers with wet sand in the cavity, which is able to maintain low humidity and to lower the inner temperature below the environment one. This solution does not require the use of energy and it is suitable for preserving fruit and vegetables. They developed a system of containers that can be integrated in any European domestic environment.

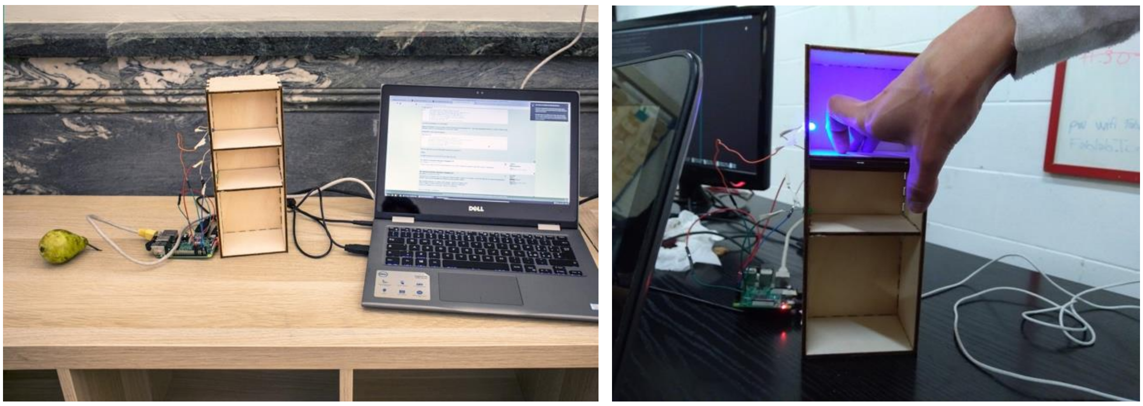

Figure 3: Machine learning, voice recognition and shape recognition of food

[2] Pot-in-pot is a traditional African system that is used to cool the temperature of foodstuffs, which is achieved through direct evaporation generated by exposing the container to the sun.

Figure 4: Temperature and humidity monitoring prototypes

A gaming-based education system which benefited from augmented reality and learning systems won the third challenge (type 1) on Visionary solutions. The students were supported by computer scientists, natural scientists and researchers in the field of Information and Communication Technologies.

Survey results

The results of the two surveys distributed to the CLabTo participants, which resulted in a high response rate of 90.3% (56 students out of 62) were used to form the survey sample. The surveys were given to the participants before and after the challenge, and they are here referred to as the pre-challenge and post-challenge surveys.

To assess the extent to which the CLabTo classes and team experience contributed to fostering the professional development of the students, they were asked. in both the pre- and post-surveys, to provide a self-assessment of their capabilities and perceived expertise in each of the six skills listed in Table 1. These entrepreneurial skills were taken from GUESSS[3].

Table 1: Six skills on which the students were asked to give a self-assessment

Skills					
Creating new products and services	Managing innovation within a firm	Commercialising a new idea or development	Building up a professional network	Identifying new business opportunities	Successfully managing a business

The first three items refer explicitly to the innovation and development of new ideas/products/services. The fourth one is about belonging to a professional network, while the last two refer to vision and management business aspects.

The students' self-declared capabilities were ranked on a 5-point Likert scale, where 1 refers to very low competence, 2 refers to minimally capable, 3 to adequate, 4 expresses good competence and 5 refers to very high competence. The results are shown in Figure 5.

[3] GUESSS is a large, global research project on student entrepreneurship. More information is available on: http://www.guesssurvey.org/.

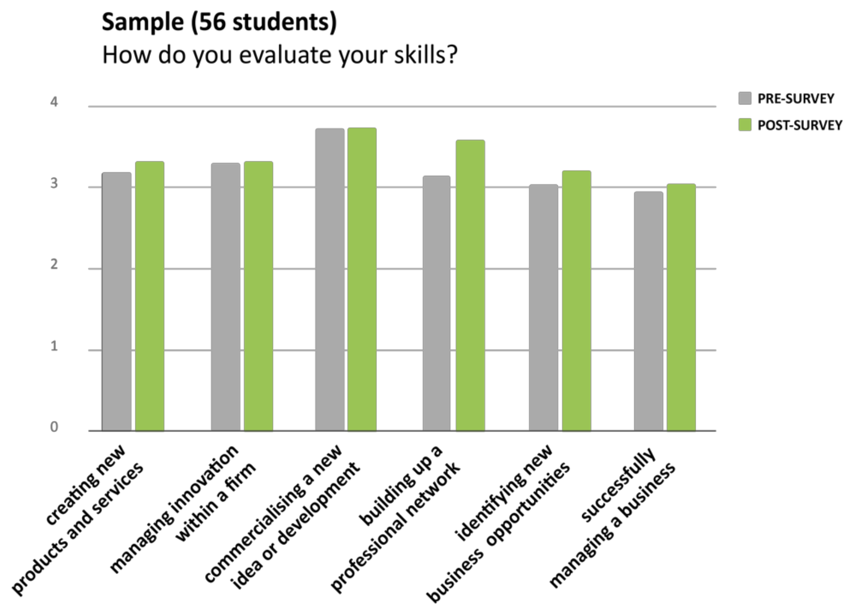

Figure 5: The overall perception of students' pre- and post-challenge skills

At a first glance, it seems that the students' perception of their skills (pre- and post-challenge) increase slightly, which is a good result, considering the limited duration of the programme. However, if the data are analysed by breaking them down into the students' fields of study and their education level, it can be observed that some students benefited more than others from this type of education. The remaining part of this section is dedicated to discussing the obtained data by exploring what happened according to the different education levels of the students (graduate and undergraduate) and the different fields of study (Design&Architecture, Engineering, Humanities, Management, Natural Science).

Differences in results for the BSc and MSc students

On entry to the programme, the BSc students differed from the MSc students for all the capabilities; the results indicate that the MSc students (39 individuals) perceived higher capabilities than the BSc students (16 individuals) (Figure 6). However, at the end of the programme, the situation was completely reversed, with the MSc students feeling they had little or no gains, while the BSc students perceived a greater gain, as shown in Figure 7.

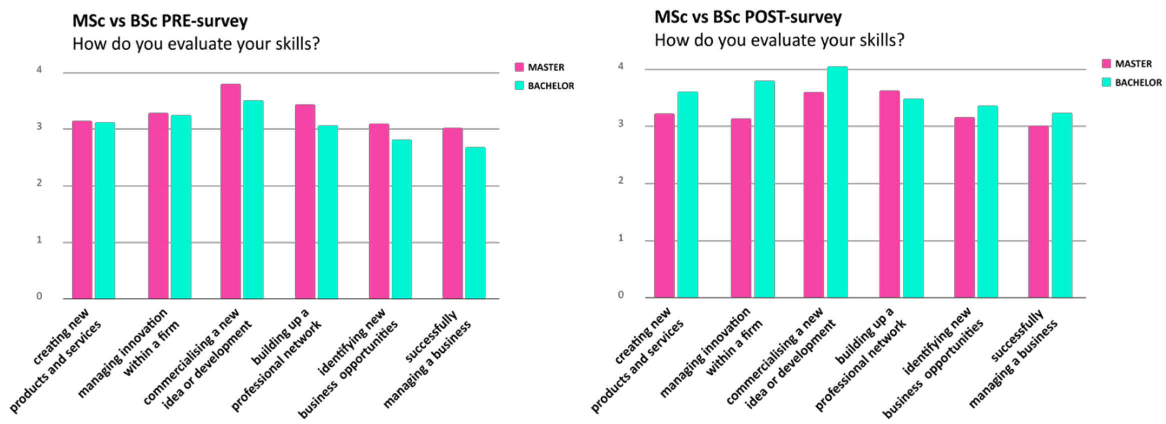

Figure 6: The perception of the MSc and BSc students on entry to the programme and at the end of the programme

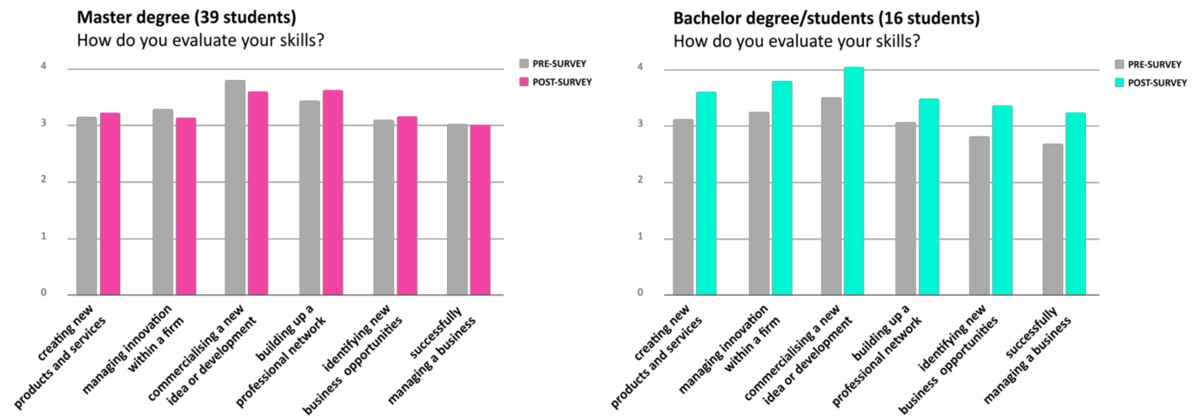

Figure 7: The perception of the MSc and BSc students about their skills (pre- and post-challenge)

Comparing the pre- and the post-challenge perceptions, it emerges that the Bachelor students showed the greatest gain in perceived skills during the course. It also emerges that the MSc students, in some cases, perceived a decline of their skills, such as “managing innovation” and “commercialising a new idea or development”. However, since our sample is only composed of 56 students (even though they answered on both the pre- and post-challenge) and no control sample was available, our results can only be considered qualitative.

The results according to the students’ backgrounds

In addition to the difference between the MSc and BSc students, the perceived skills of the students are presented in this section, divided according to the fields of study (Figure 8).

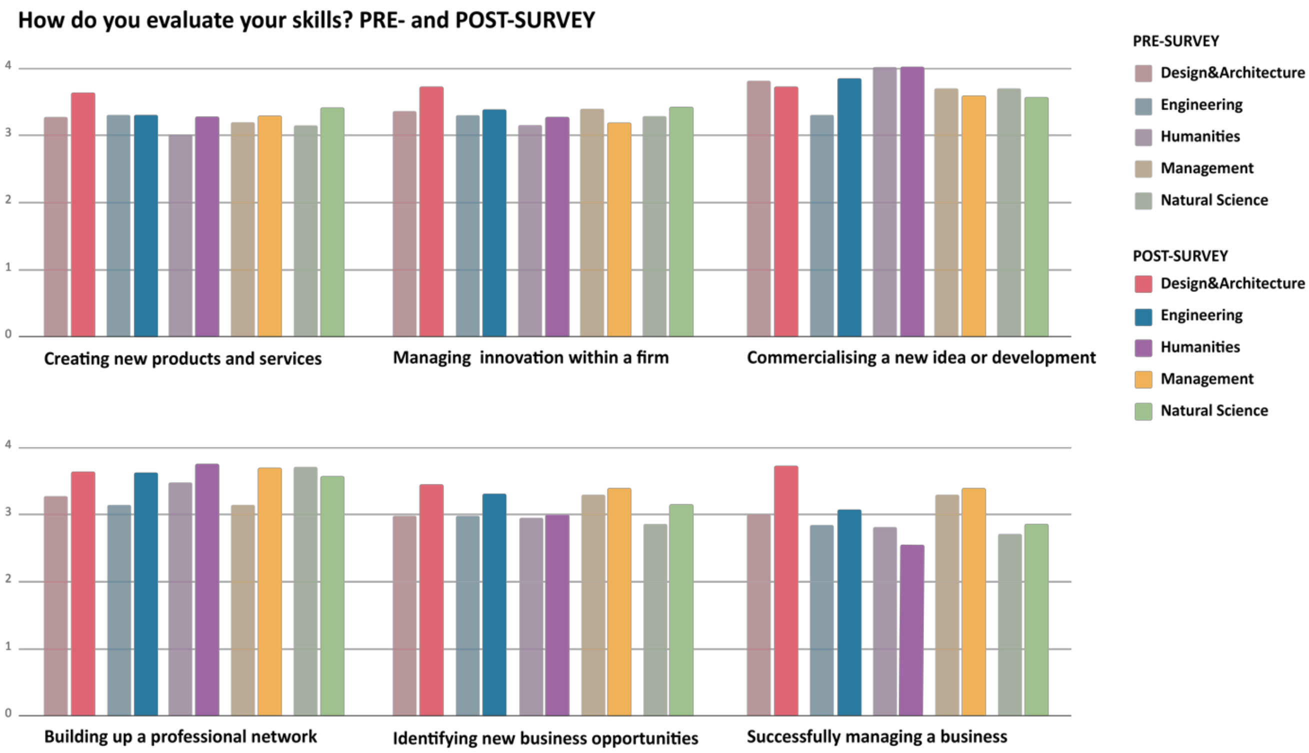

Figure 8: The students’ perception of their entrepreneurial skills according to GUESSS.

As far as the two innovation-related aspects, i.e. “Creating new product/services” and “Managing innovation within a firm” are concerned, an increase was observed from the entry to exit levels for all the student categories, except for the management students who declared a decrease in “Managing innovation within a firm” from the pre- to the post-surveys. Designer students experienced the greatest gain, and they were followed by the natural scientists. This may indicate that this entrepreneurial course and the CLabTo's environment are able to foster these two innovation-related aspects of students from design and natural science. As far as the third innovation-related aspect (Commercialising new ideas or development) is concerned, this entrepreneurial skill decreased for all the students, except for the engineers. We have hypothesised that this is due to the fact that all the students had over-evaluated their capabilities on entry and found themselves facing difficulties during the programme on this topic. The “Building up a professional network” skill increased significantly for all the categories, except for the natural scientists. A satisfying sense of belonging developed during the programme for all the other students. The two entrepreneurial aspects (Identifying new business opportunities and Successfully managing a business) showed a general improvement from the pre- to the post-survey, except for the students of humanities, whose skills remained almost unchanged or were even lower at the end of the programme. This may be a common problem of this category of student, but there was no evidence of it in their comments. The designers, engineers and natural scientists perceived the greatest gain in “Identifying new business opportunities”, and the designers also perceived the greatest gain in “Successfully managing a business”, and this was followed by the engineers. Those who were more skilled at the beginning of the programme, i.e. the management students, found the programme moderately useful for improving this skill.

Finally, we observed the results for each student category pertaining to each skill (Figure 9).

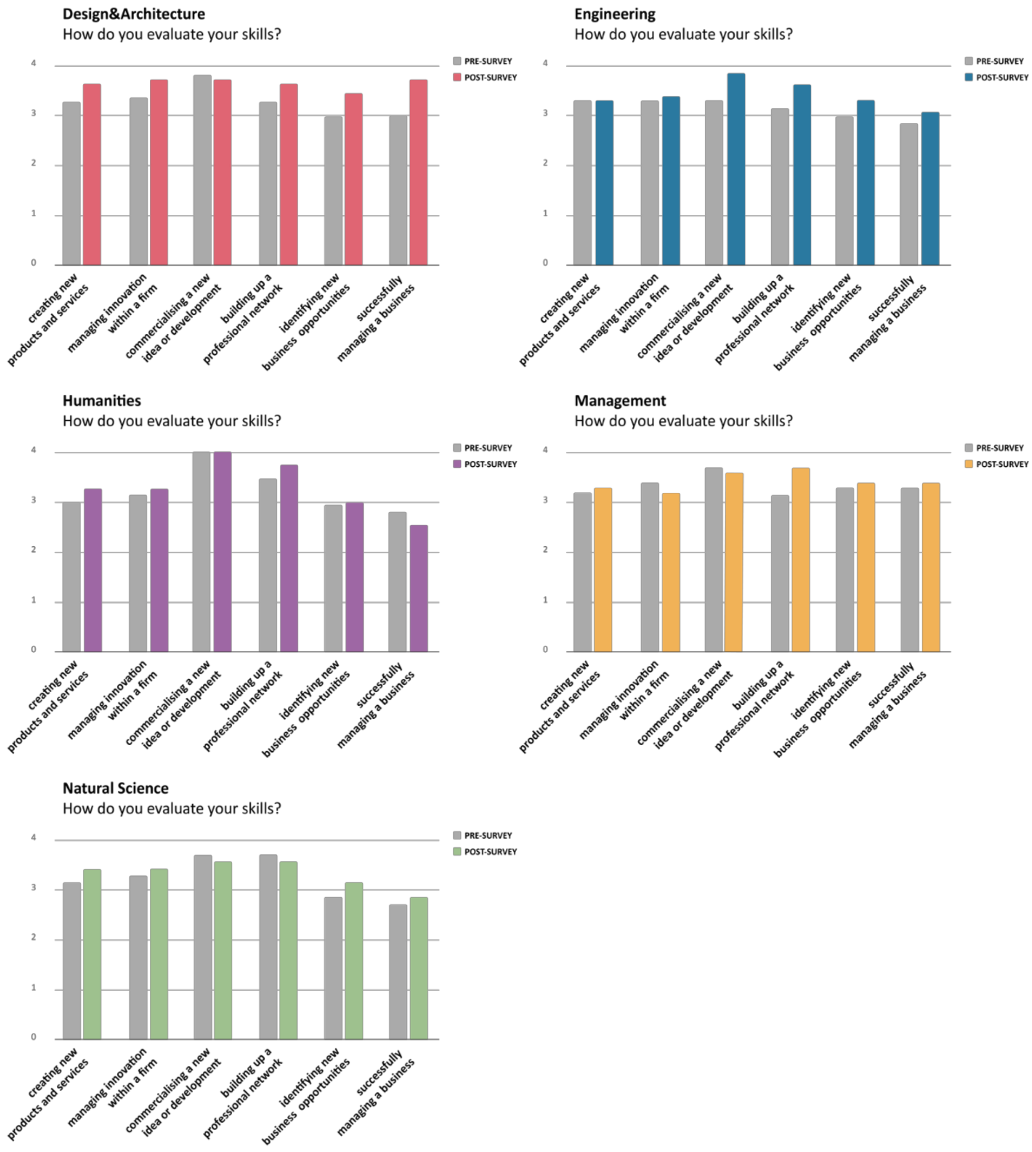

Figure 9: Students’ skills divided according to the category of student (pre- and post-survey comparison)

Although our results are qualitative, they show mixed results according to the students' fields of study.

Thus, it can be noted that:

- The Design&Architecture students perceived an increase in 5 items out of 6
- The Engineering students perceived an increase in 5 items out of 6 and one remained unchanged
- The Humanity students perceived an increase in 4 items out of 6 and one remained unchanged
- The Management students perceived an increase in 4 items out of 6
- The Natural science students perceived an increase in 4 items out of 6.

These mixed results indicate how a complex environment with students from different fields of study and different levels of education can have a different impact on the participants.

Results on the degree of satisfaction of the programme

We asked the students if they perceived the programme as being more theoretical (1) or practical (5), and to evaluate this feature over a range of 1 to 5. An average mark of 3.55 was achieved, which means that the programme was perceived as being slightly more practical than theoretical.

Moreover, we also asked the students how they considered the time dedicated to the following topics on a 1 to 5 scale (1=insufficient, 3=adequate, 5=too much):

- Teamwork: 2.77
- Presentations (Pitches): 2.91
- Support received: 2.66
- Classes: 3.11

It emerges that the students' perception about the classes is that the duration is slightly overestimated, while the time spent on team work, presentations and support received should be increased.

Moreover, as far as the overall duration of the challenges (1=insufficient, 3=adequate, 5=too much) is concerned, an average of 2.68 was obtained, which indicates a perception of the programme being slightly shorter than expected. From these results, it can be concluded that the time spent on classes was perceived as a little excessive compared to what the students expected as support for their specific projects.

The students found the material provided satisfactory as a support to develop their ideas. It was evaluated from 1 to 5 (1=insufficient, 3=adequate, 5=too much) in answer to the question "Were the available materials sufficient for the realisation of your idea?" with an average of 3.57/5. Moreover, they were asked to what extent they felt the interdisciplinary experience was useful for their team. Their answers show it was the most appreciated aspect, thus confirming that the multidisciplinary promoted by the CLabTo has been extremely enriching. In this regard, it should be noted that the provided training was also multidisciplinary, as it involved professors and experts from disparate fields. The students indicated they were satisfied with this aspect, and reported it in the free text boxes. Moreover, on the basis of the three categories of teacher presented by Béchard and Grégoire (2005), the students' perception of the teachers was mainly "as tutor and facilitator".

The teachers in the CLabTo programme are in fact encouraged to facilitate debates, share learning, interact and brainstorm. Dziuban et al., (2004 p.3) and Nielsen and Stovang (2015 p 985) suggested a shift from lecture- to students-centred instruction in which the students become active learners, and an increase in interaction between students and teacher is encouraged. One of the questions in the post-survey was related to this aspect, and the perception of the students about their role was mainly that of "active participant with a close interaction with the teachers" (Fiore et al., 2019)

Finally, we asked the students if they thought this programme had overall increased their interest in innovation (evaluated from 1 to 5), and we received positive feedback, with an average mark of 4,45/5.

Discussion and conclusions

In recent years, the focus on the innovative value of design thinking in businesses and business education has increased (Nielsen and Stovang, 2015). In this paper, we provide new insights into how to develop EE through design thinking, teaching methods, teacher-user relations, teaching and team working environment. CLabTo offers a unique programme for EE as it provides EE for all the different types of university students in the form of a practice-oriented design-led programme. The students faced real-life challenges as well as entrepreneurial ones, and the programme helped the students to acquire communication and networking skills, while working in transdisciplinary teams to develop entrepreneurial tasks (Ball, 2003).

Design is seen as a valuable route to accomplish business goals and new entrepreneurial opportunities (Nielsen and Stovang, 2015; Clark and Smith, 2008; Boland and Collopy 2004). CLabTo has thus allowed design and business pedagogy to be merged for their mutual enrichment, by identifying new business opportunities, and anticipating and creating an unknown future (Nielsen and Stovang, 2015).

We tested our model on students with different educational levels and from different fields of study, and introduced teaching, tutoring and mentoring in which a variety of professors, researchers and experts from different fields were involved. We created a learning environment in which the students and their creativity in delivering innovative solutions were stimulated, with the help of prototyping, visualisation techniques and idea generating support.

As previously noted, a multidisciplinary team approach is a key element of such a programme (Thursby et al., 2009) and it was the aspect that was most appreciated by the students, as shown in some comments to the question "What worked best during the programme?" (Fiore et al., 2019) in which they recognised the role of the Psychologists in the team building phase.

- *"The advice of the group of psychologists for the creation of groups"*
- *"Working in a group with different skills"*
- *"Multidisciplinary allowed us to develop a real project"*
- *"Interacting with different people from different universities. This meant that each of us put his/her own expertise into the project"*
- *"Interdisciplinary groups"*
- *"Being all immersed in something new and unexpected. Regardless of the background, perceiving yourself as similar to others and being able to create in an environment without prejudices and that is only aimed at your growth"*

Teamwork is the students' most commonly mentioned benefit of the programme. For example, in the exit surveys the students were asked "What worked best during the programme?" Of the 56 respondents, 67% of them listed "team" or "teamwork" as one of the most important aspects of the programme. Moreover, the programme has been perceived as being more practical than theoretical, which is in line with our goal. Another relevant result is that the students found that the programme increased their interest in innovation.

As far as teaching is concerned, achieving a pedagogical delivery that simultaneously engaged all the student groups was challenging. We decided to create our own courses and use our own material instead of resorting to those of the two involved universities. The first reason why the programme could not benefit from the teaching of ongoing courses is that they are difficult to access. We in fact needed to cover specific topics on specific days and at specific times, because of the restricted duration of the challenge. The second reason is that the module had to balance the differences in students' background, that is, by trying to keep some parts generic and easily understandable with examples and case studies, while providing some more technical contributions for the students who had the necessary knowledge to understand it and use it during the team work. The key for the class structure is delivery to inform those with limited backgrounds, while avoiding boring those with in-depth knowledge (Thursby et al., 2009). Thus, our classes tended to focus on content for an hour or two, with practical implications on the projects that the students were working on. The teachers became aware of the heterogeneity of the audience and changed their way of explaining to a more interactive and engaging way; this was facilitated by the limited number of participants in each challenge (from 32 to 15). The approach we have undertaken appears to have been successful, as shown by the following comments to the question "What worked best?"

- *"Expert interventions. They have been very useful to approach a new way of assessing the challenge"*
- *"The initial lessons of the various professors allowed us to focus on and study the theme in question in more depth"*

- *“The insights given by the lessons and the mixed groups were good incentives to look for new ideas”*
- *“The multidisciplinary nature of the lessons and the teams”*

The evaluation, by means of pitching instead of written or oral examinations, was also appreciated by the students, as may be seen from two comments to the question “What worked best?”

- *“The final pitch with the jury was a great stimulus”*
- *“Time schedule, pitches, multidisciplinary lessons and teams”*

As already highlighted by Thursby et al., 2009 with another EE programme, although our data are self-reported perceptions, it is clear from our empirical analysis that the described programme had some effects on the students’ perceptions of their ability. Both on entry and exit from the programme, we found some differences, according to the fields of study and MSc/BSc background, in the perceived capabilities. Moreover, the greatest gains were shown for the BSc students and designers, followed by the engineers. However, there was an overall increase in each skill, which is a good result, considering the limited duration of the programme (2 weeks).

A better management of time, an extension of the duration of the programme and the need to increase the presence of tutors are some of the aspects that still need to be improved. Moreover, it was noted that some students did not to attend 100% of the classes, probably as a result of a lack of credits. Each aspect of the challenge of developing such an integrative programme is significant, that is, from recruiting students, to planning the teaching activities and the team work, to managing the time of each activity. As far as pedagogy is concerned, the most challenging aspects were finding suitable professors to satisfy the CLabTo approach and the specific teaching delivery required for the challenge. Each challenge in fact required *ad hoc* teaching planning. The CLabTo programme, with its focus on idea generation and transdisciplinarity (pertaining to both the fields of study and the education level), makes an important contribution to EE, as it offers the possibility of working across disciplines. The model may lead students to acquire all the capabilities needed for their future careers in innovation (Thursby et al., 2009). Echoing the hope of Nielsen and Stovang (2015), we hope to have contributed to the discussion by creating knowledge about the cross-over of design thinking and EE.

Limits and future research

In our study, the survey data were based on a limited number of students and no control sample was available, therefore, our analyses can only be considered qualitative. Moreover, we considered a single case study (CLabTo) in Italy and it is therefore not possible to generalise. However, the sample is representative of the population of students who took part in the CLab Torino programmes. Moreover, our results may be different from those of other countries, since different cultures can lead to different results. For example, Mueller and Thomas, (2001) and Giacomin et al., (2011) suggested some variables that should be taken into account in order to study EE in different countries. Therefore, it could be interesting to include students with different cultures and to study the differences in addition to the multidisciplinary nature of their backgrounds, thus creating not only multidisciplinary teams with different educational levels, but also bringing different cultures together.

In addition, since corporations seem interested in employees with entrepreneurial competencies, it could be interesting to analyse whether employees who have taken part in EE classes are more innovative than those who have not participated in EE classes; this could be achieved by introducing control samples.

Given these assumptions and the results of the survey, we believe that the process of creating an entrepreneurial programme for all types of university students, and which would be suitable to fit all the different circumstances, will take from 3 to 5 years of continuous tests and iterations. Thanks to the students' feedback, in the next challenges, we will test new forms of teaching and tutoring during the team work in order to improve the programme and to make it useful for both those students who decide to create their own businesses and those who want to work in multidisciplinary teams in innovative contexts. We believe that this entrepreneurial programme could lead to cooperation with universities outside Italy, but this would require a non-trivial effort to convince different professors and Universities to collaborate in a common project.

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