Advances in Engineering Education

FALL 2021

Offering an Entrepreneurship Course to All Engineering Students: Lessons Learned from ING2030 in Puc-Chile

ISABEL HILLIGER

CONSTANCE FLEET

CONSTANZA MELIAN

JORGE BAIER
Pontificia Universidad Católica de Chile
Santiago, Chile

MAR PÉREZ-SANAGUSTÍN
Université Toulouse III Paul Sabatier
Toulouse, France

ABSTRACT

Entrepreneurial learning experiences have become one of the key aspects of the state of the art in engineering education. As such, technology-focused entrepreneurship courses have been incorporated to engineering curricula — both in developed and developing countries. Following this trend, the Engineering School at Pontificia Universidad Católica de Chile (PUC-Engineering) designed a third-year compulsory course on research, entrepreneurship, and innovation, whose objective is to provide students with entrepreneurial skills that transcend time. To continuously improve this course, the Engineering Education Unit at PUC-Engineering has been conducting pre- and post-surveys, assessing self-efficacy and learning benefits related to various course methods. This paper describes the main lessons learned as a result of using this data-centric approach throughout the last six academic periods. We found that the course is perceived as beneficial by most of its students, and that project feedback sessions and project presentations report the highest perceived learning benefits. Besides, we describe some of the improvements to the course that have been pushed by assessment data, showing the importance of using a data-driven approach for engineering entrepreneurship education.

Key words: Entrepreneurship; Engineering Curriculum; Assessment

INTRODUCTION

Over the past two decades, engineers have become key stakeholders in venture creation, either creating or participating in entrepreneurial initiatives (Wright et al., 2007). As a consequence, policy interventions have promoted the creation of entrepreneurship programs in engineering education (Duval-Couetil et al., 2016; Maresch et al., 2016). ‘Economic trends and a changing job market for college graduates have generated significant interest in graduating more engineers who possess entrepreneurship skills and an entrepreneurial mindset’ (Duval-Couetil et al., 2014, p. 1). Through entrepreneurial training, future engineers are expected to adapt to the changing and complex technologies, and drive the generation of solutions to major technological problems — both locally and globally (Purzer et al., 2016).

In developed countries, there has been a significant growth in the delivery of entrepreneurial learning experiences to future engineers (Celis & Huang-Saad, 2015; Gilmartin, Shartrand, Chen, Estrada, & Sheppard, 2016). The most prestigious universities in the world have implemented technology-focused courses that have been typically offered as part of minors and certificates (Duval-Couetil et al., 2014; Gilmartin et al., 2016). Meanwhile, in developing countries, these types of courses have recently started to emerge (Moreno et al., 2016; Odora, 2015; Raju et al., 2015), and promising results are expected in entrepreneurial activity and the acquisition of entrepreneurial skills (Duval-Couetil et al., 2014; Walter & Block, 2016).

Following this trend, engineering programs have started to implement practical experiences based on project- and team-based learning (Rae & Melton, 2017). However, more research is needed to understand what is expected from entrepreneurial training and what are the proper pedagogical approaches for its delivery (Huang-Saad et al., 2020). So far, the contribution of entrepreneurship education has been assessed throughout different methods, such as quizzes, project deliverables and surveys, without necessarily using an educational model to interpret its results (Purzer et al., 2016). In order to contribute to the growing field of engineering entrepreneurship education, this paper describes the lessons learned from having offered an entrepreneurship course to all third-year students at the Engineering School of Pontificia Universidad Católica de Chile (PUC-Engineering). This course was implemented in the context of a governmental program called ‘New Engineering 2030’ — an initiative which co-finances 6-year strategic plans of Chilean engineering schools oriented towards entrepreneurship, innovation, and technology transfer (Celis & Hilliger, 2016). This paper briefly describes the course teaching and assessment methods, besides the results of having systematically assessed learning benefits and self-efficacy changes throughout Pre- and Post-Surveys.

ING2030 COURSE: RESEARCH, ENTREPRENEURSHIP, AND INNOVATION

The dean of PUC-Engineering motivated the creation of the Research, Entrepreneurship, and Innovation Course (ING2030) at the end of 2014, and third-year students have been taking this course since the first semester of 2015 (http://bit.ly/ING2030Syllabi). Unlike elective courses offered at other engineering schools, this course is mandatory for all engineering Majors. It was designed following the Berkeley Method of Entrepreneurship (BMoE) (Sidhu et al., 2014), which consists of a holistic curriculum to provide students with entrepreneurial knowledge and skills, along with offering them the opportunity to develop a positive attitude towards entrepreneurship. According to this method, teaching staff act as facilitators, allowing learners to identify concepts and tactics associated with entrepreneurship through game-based activities and inductive teaching.

Since 2015, the course has been imparted by a teaching team composed of instructors, entrepreneurs, and teaching assistants. Regarding instructors, there are two predominant profiles: the ones with an industrial engineering background and the ones with a civil engineering background. The ones with an industrial engineering background have prior experience in technology-based innovation and entrepreneurship methodologies (as managers and/or researchers), while the ones with a civil engineering background have prior entrepreneurial experience in their own field. With respect to entrepreneurs, these are people who have been actively involved in the creation and growth of one or several startups, so they have the capacity to share with students and other teaching team members their perspectives about current entrepreneurial practice. Finally, concerning teaching assistants, they are mainly graduate or undergraduate students who have already taken the course, and who are trying to carry out their own ventures by participating in extracurricular programs of the university's innovation ecosystem.

In order to make this course as authentic as possible in terms of the complexity and uncertainty of becoming an entrepreneur, the course challenges students to develop an innovative product or service throughout 16 weeks. Some examples of the challenges that we have been addressed in the course are universal access to water — second semester of 2018 (https://youtu.be/ZJKiJ4Xudao), engineering for sustainable development — first semester of 2020 (https://bit.ly/3gSokPI), and innovation in the new space age — second semester of 2020 (https://bit.ly/3we77tb). By working as part of 5-person teams, students have to recognize a technology business opportunity to compete in a venture contest by the end of the semester (see the venture contest of the first semester of 2020 at https://youtu.be/Ty5Yw8sbl6w). Winning teams receive seed funding and are encouraged to apply to PUC-ecosystem acceleration programs for developing their entrepreneurship projects beyond their course experience.

Between the first semester of 2015 and the second semester of 2018, the course focused mainly on motivating engineering students to become entrepreneurs. However, this emphasis on entrepreneurial intent was contradictory to PUC-Engineering's desire to provide all their engineering students with knowledge and skills associated with entrepreneurship, regardless of their intention to become entrepreneurs today or in the near future. This is why the course coordinator started adapting the

BMoE curriculum since the first semester of 2018, implementing project-based learning with a constructivist theoretical basis. By a constructivist theoretical basis, we refer to the conceptualization of entrepreneurial learning as a process of constructing knowledge throughout a continuous dialogue with peers, teaching staff members, and real-life entrepreneurs (Assudani & Kilbourne, 2014; Löbler et al., 2019). Recent work has shown that constructivist approaches have been more effective in developing entrepreneurial skills, allowing students to engage in tasks that are directly associated with what entrepreneurship could be in their future practice (Bell & Bell, 2020; Löbler et al., 2019). At PUC-Engineering, a constructivist approach such as project-based learning was used to align course teaching and assessment methods with steps involved in the entrepreneurial process, allowing students to develop the following skill set, regardless of students' entrepreneurial intent:

- An ability to identify an opportunity for the creation of an innovative product or service within a context or topic,
- An ability to develop a business model for a product or service which should be supported by a scientific and technological basis,
- An ability to collaborate effectively in teams to develop an innovation project,
- An ability to design an innovative project or service based on science and technology with scaling potential,
- An ability to use data for evidence-based decision-making to reduce the level of uncertainty associated with real-life problems,
- An ability to effectively communicating ideas about technology-based innovations in oral and written format.

In order to develop the abilities previously listed, the course covers the following topics: (1) entrepreneurial concepts and vocabulary, (2) effective teams, (3) context and PESTEL framework, (4) Lean Startup Methodology, (5) customer development, (6) technology watch, (7) design sprint methodology, (8) prototypes and minimum viable product, (9) ethics in entrepreneurship, (10) Startup funding, (11) Pitch, (12) intellectual property, and (13) scaling and growth. These topics are covered through the combination of different teaching methods and business accelerator elements, including:

- Project feedback sessions: instances in which course instructors and an entrepreneur meet separately with each team to provide feedback on their project progress.
- Instructors' lectures: classroom sessions that combine the delivery of theoretical content with activities, allowing students to learn different concepts and methodologies that are relevant to developing an entrepreneurship project.
- Working sessions: classroom sessions dedicated to teamwork, in which students are asked to work on a project deliverable under the supervision of teaching staff.

- Mentoring: these sessions are offered twice a semester, one in the middle and one towards the end, so teams have the opportunity to meet with an entrepreneur or an expert of their choice for at least 20 minutes, receiving feedback and guidance to progress on their projects.
- Guest lectures: these lectures are offered throughout the semester (eight sessions per semester on average), and in each session, guests offer a talk about a topic related to the challenge that the course is addressing during the semester or stories related to real-work entrepreneurship, and then, there is a question and answers session.
- Workshops: these sessions engage students in skill-building activities related to the use of digital tools for virtual prototyping, pitch, and presentation design. Each team member chooses one workshop, so they can share knowledge later.

For promoting the effective work of student teams, one class imparted at the beginning of the semester is specifically dedicated to this topic. This class addresses the advantages of heterogeneous teams that have a common motivation or goal, along with team building theories, such as Tuckman's model of team development (Tuckman, 1965), or Wasserman's founder dilemma (Wasserman, 2012). Besides, students participate in a team-based activity where they have to choose their team members (usually homogeneous in terms of skills and preferences), and then, they do the same activity in teams designed by the teaching staff, which are based on common motivation and different skills. Finally, the students have to decide how they want to build their teams for their course project, but they are strongly encouraged to reflect about their experience in the teambuilding class and to distribute different roles among team members, such as the hipster, the hacker, and the hustler (Ellwood, 2012).

Throughout each academic period, different instruments are used for course assessment and evaluation. Concerning learning assessments, students are required to do homework and take written exams or quizzes to demonstrate their understanding of entrepreneurship concepts. Besides, they are required to do project presentations and elaborate written reports assessed by external evaluators from private and public entrepreneurial funds. Project presentations include group presentations at four stages of product development: problem detection, solution mock-up, solution prototype, and a final presentation. Besides, in every project presentation, peer assessments are also conducted to allow evaluation of their teamwork skills, including commitment, communication, and conflict resolution.

Since 2018, the teaching team has been mostly stable, what has allowed the conduction of course evaluations at the end of each semester based on data collected throughout Pre- and Post- surveys (more details in the methods section). Figure 1 shows the improvement actions that have been implemented over the last five academic periods based on this evidence. Over the semesters, the course has incorporated more working and feedback sessions to not only allow students to work on their projects under the supervision of teaching staff, but to also receive timely feedback about their progress. Besides, the course has incorporated a higher number of mentoring sessions with both technology

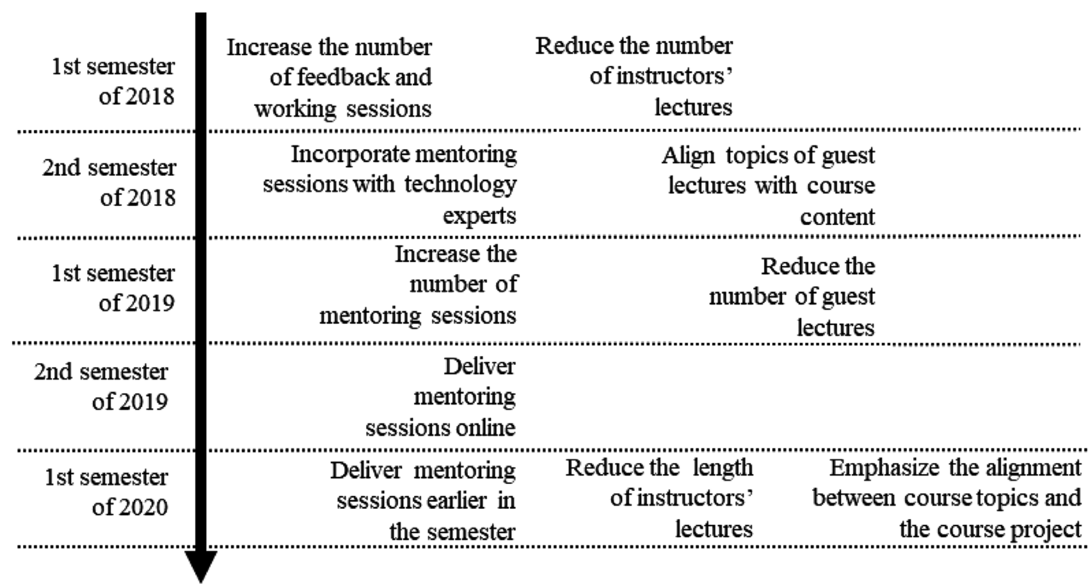


Figure 1. Improvement actions that have been implemented in ING2030 course over the last semesters.

and business experts to ensure that all teams receive guidance on specific aspects of their product or service. The coordination of the course has also worked in the constructive alignment of different course elements, optimizing the delivery of guest lectures, instructor lectures, and course topics.

Although the focus of the course has shifted from focusing on entrepreneurial intent to developing entrepreneurial skills, there are teams that decide to go beyond the course by transforming their course projects into actual startups. Some examples of these cases are the following:

- B-Cycle: This team won the venture contest held at the end of the first semester of 2019, and its project consisted of biodegradable and compostable beer bio packaging made from barley waste from the brewing industry. After the course, they participated in further acceleration projects, and in 2020, they were awarded a public fund of 34,000 USD.
- CmSonic: This team took the course during the first semester of 2018. Although they did not win the venture context, they still participated in extracurricular entrepreneurial initiatives within the university. Currently, they transform non-recyclable materials into recyclable by using ultrasound (e.g., transforming discarded cement sacks into recyclable paper). In 2020, they were awarded a public fund of 63,000 USD.
- LighWash: This team won the venture contest during the first semester of 2019. The project started as a waterless clothing washing machine with UV light. With the beginning of the pandemic, they transformed their project into a startup focused on sanitizing health equipment

and uniforms with UV-C light technology. They worked intensively in 2020 by disinfecting equipment and uniforms of different institutions such as hospitals and firefighters, and they were awarded a public fund of USD 83,000.

METHODS

Research Objective and Design

This paper aims to contribute to engineering education by sharing lessons learned from offering the ING2030 course to all third-year students at PUC-Engineering in Chile. These lessons learned were captured from analyzing Pre- and Post-Surveys that were implemented to formulate improvement actions at the end of every semester. Specifically, this paper presents the results from the last six academic semesters —1st semester of 2018 (1-2018), 2nd semester of 2018 (2-2018), 1st semester of 2019 (1-2019), 2nd semester of 2019 (2-2019), 1st semester of 2020 (1-2020), 2nd semester of 2020 (2-2020) — and the lessons learned from their analysis.

Data Gathering Techniques and Participants' Sample

Every semester, the Engineering Education unit conducts a Pre-survey during the first two weeks of the ING2030 course (weeks 1 and 2), and a Post-survey once the classes are finished (weeks 17 and 18). The Pre-Survey includes measurements regarding demographics (year of birth, gender, participation in extracurricular activities, and prior exposure to family entrepreneurship), while the Post-survey includes a 5-point Likert scale to measure students' perceptions on learning benefits from course teaching and assessment methods.

Considering that one of the objectives of entrepreneurship courses is to help students discover the skillsets they possess (Assudani & Kilbourne, 2014), as well as their potential areas of improvement, we also included a scale self-efficacy in the Pre- and Post-surveys. By self-efficacy, we mean Bandura's construct (1977), which refers to 'the strength of a person belief that he or she is capable of performing the various roles and tasks of entrepreneurship' (Chen, Greene & Crick, 1998, p. 295). To measure the self-efficacy changes, we adapted a self-efficacy scale of ten items proposed by Cooper and Lucas (2006) (see self-efficacy scale by following the link: http://bit.ly/ING2030_self-efficacy). Before the first semester of 2015 started, this scale was tested throughout four cognitive interviews with alumni by following a think out loud protocol (Ryan et al., 2012), besides being revised by one international expert in engineering entrepreneurship education. Then, we applied the self-efficacy scale at the beginning and at the end of the first semester of 2015 to conduct a statistical validation of internal consistency and construct validity. Regarding internal validity, Cronbach's α values ranged between 0.74 and 0.89, demonstrating high reliability and no redundancy in the items (Bonett & Wright, 2015). Regarding

Table 1. Students who participated in Pre and Post surveys applied during the ING2030 course in the last six academic periods.

	1-2018	2-2018	1-2019	2-2019	1-2020	2-2020
Course enrollment (N)	370	252	387	326	384	403
Pre-Post sample (N)	267	167	266	201	206	194
Response rate (%)	72%	66%	69%	62%	54%	48%
Female students (%) (*)	25%	30%	35%	34%	25%	32%
Students aged 20-21 (%) (*)	88%	76%	77%	76%	68%	59%

(*) These percentages correspond to the Pre-Post sample. Students aged 20–21 are a proxy to describe the percentage of 3rd-year students.

construct validity, Kaiser-Meyer-Olkin (KMO) tests were used to measure how suited was the data of each scale for confirmatory factor analysis of one factor, and the KMO results of the self-efficacy scale were meritorious in the ING2030 course, ranging between 0.72 and 0.87 (Beavers et al., 2013).

Table 1 shows the number of students who participated in the Pre- and Post-surveys applied to students of ING2030 between the first semester of 2018 and the second semester of 2020. On average, 62% of the students participated in both surveys, providing self-reported self-efficacy levels at the beginning and at the end of the semester, besides perceived learning benefits at the end of the course.

Data Analysis Plan

We analyzed the data separately to contrast the data obtained from these six periods. Concerning self-efficacy levels, we estimated significant changes of the average scores of the self-efficacy scale. To do this analysis, we previously calculated the overall scale score as a summation of the responses selected by a respondent for the ten items. Then, we matched the overall scale score obtained in the Pre- and the Post-survey for each student by using the students' identification number. Then, we conducted *t*-tests in SPSS to analyze the statistical significance of the pre-post differences of the averages in both periods. Regarding learning benefits, we considered respondent scores that were equal to or higher than 3, taking into account that the scale ranged from 1 (not beneficial) to 5 (extremely beneficial). Besides, improvement actions were extracted from end-of-semester meeting minutes, to provide additional information for interpreting results and capturing lessons learned.

FINDINGS

Figure 2 shows the percentages of students who perceived learning benefits from the teaching methods that are used in the ING2030 course. Project feedback sessions are perceived to be beneficial by an important percentage of students, ranging from 69% to 89% in the last six academic

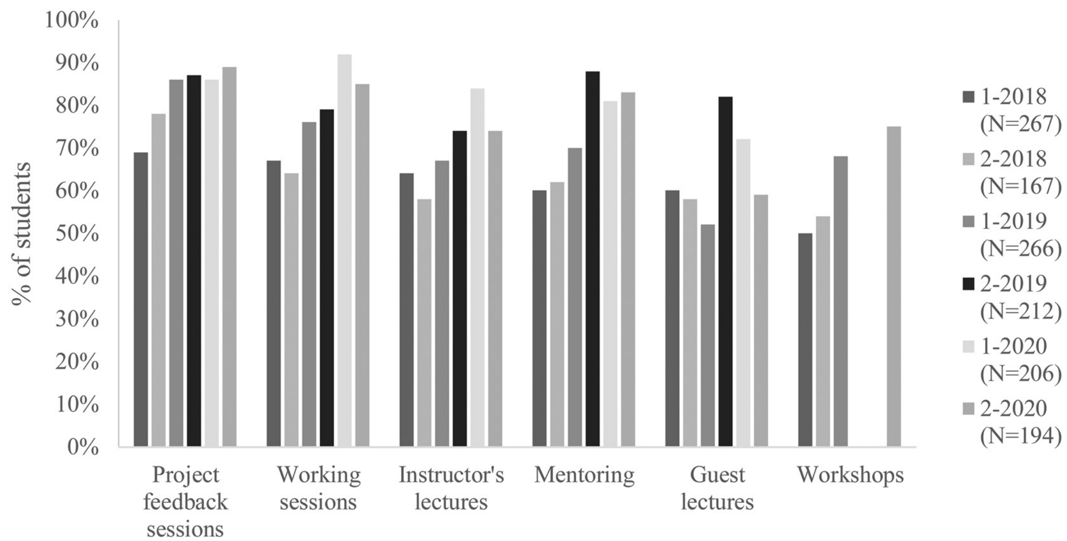


Figure 2. Percentage of students who perceived learning benefits from different teaching methods used in the ING2030 course.

periods. The other teaching methods have been perceived to be beneficial by a higher percentage of students in the last two academic periods, particularly mentoring and working sessions.

Regarding learning assessment, Figure 3 shows the percentage of students who perceived learning benefits from different assessment methods used in ING2030. Project presentations are perceived

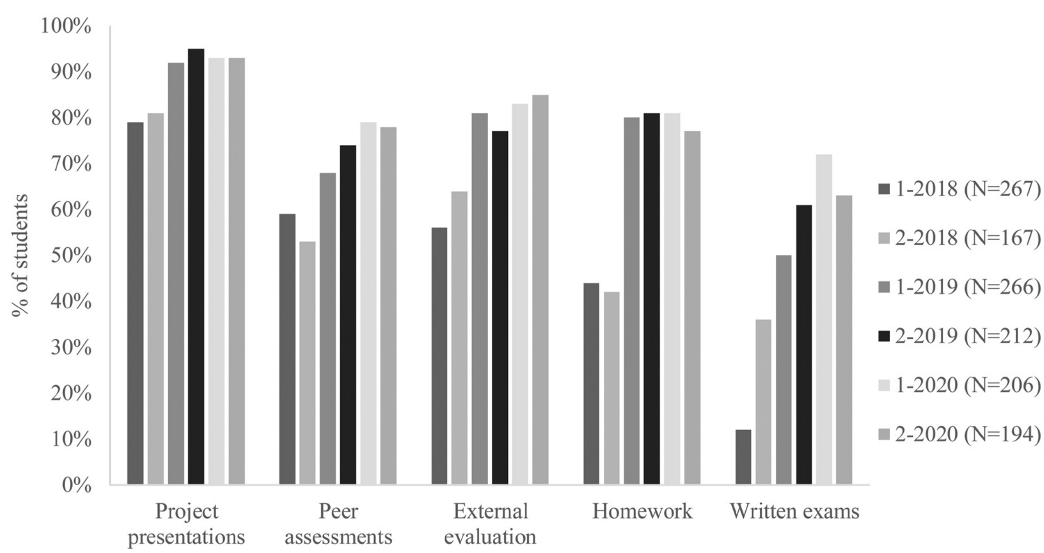


Figure 3. Percentage of students who perceived learning benefits from different assessment methods used in the ING2030 course.

to be beneficial by an important percentage of students, ranging from 79% to 93% in the last six academic periods. Whereas the other assessment methods have become beneficial for a higher percentage of students in the last three academic periods. Even written exams were perceived to be beneficial by 72% and 62% of the Pre-Post survey respondents during the first and second semester of 2020, despite being a more traditional methodology (and not necessarily experiential).

Despite the different perceptions that students have regarding course teaching and assessment methods, the overall results indicate that this course has been perceived as beneficial by most of its students. Figure 4 shows that 66% of the students considered the ING2030 course beneficial for their learning at the end of the first semester of 2018, and this percentage increased to 80% at the end of the second semester of 2020. With respect to self-efficacy changes, Figure 5 shows that the average scores of students' self-efficacy have significantly increased every semester when comparing pre and post results, while Table 2 reveals that most self-efficacy changes per item have also significantly increased in most cases, particularly in the first semester of 2020. Although the self-efficacy changes were not statistically significant during the second semester of 2020 (and negative for some items related to entrepreneurial tasks — as shown in Table 2), students still exhibited a significant improvement in their capacity to design a business model that is scalable and replicable outside Chile, as in the first semester of 2018 and the first semester of 2020.

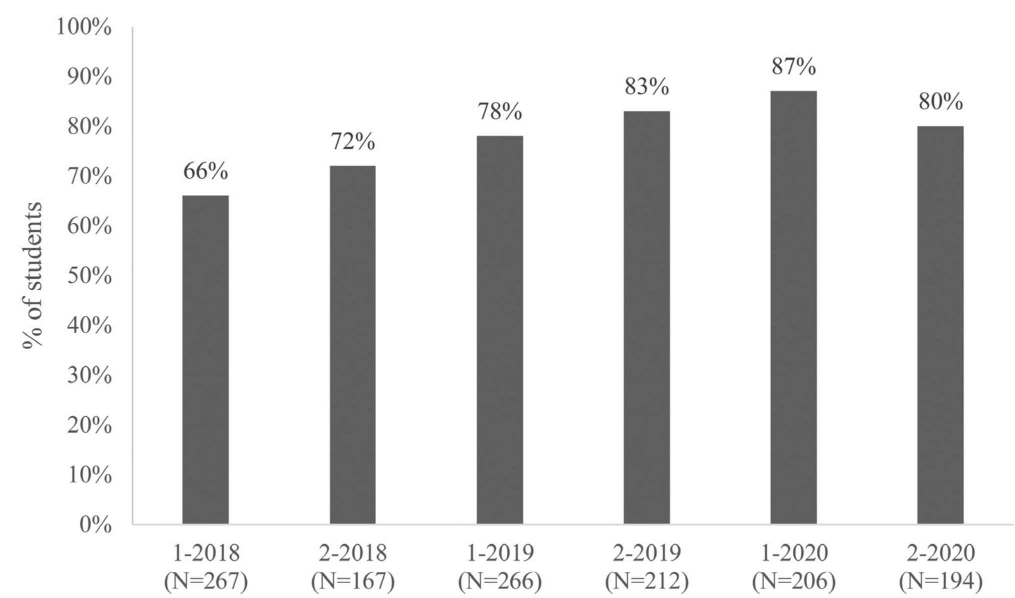


Figure 4. Percentage of students who perceived learning benefits from the ING2030 course as a whole.

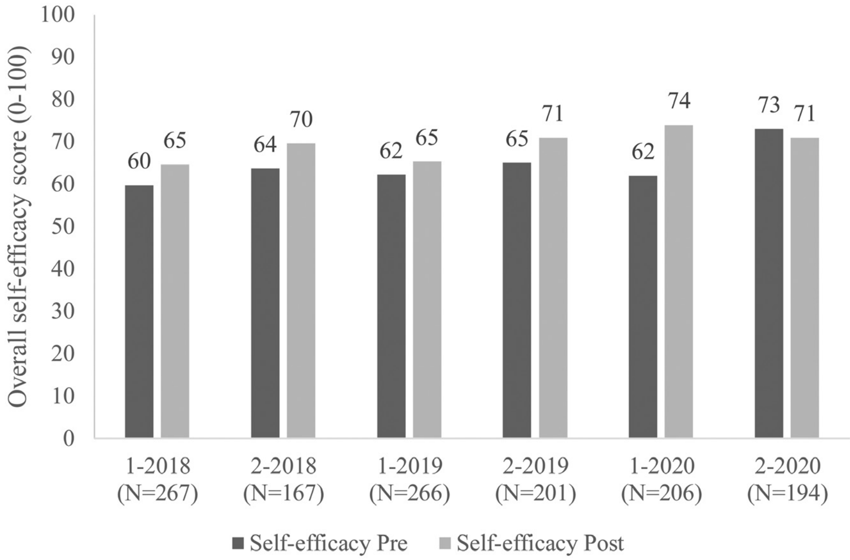


Figure 5. Average Self-efficacy scores at the beginning (Pre) and at the end (Post) of the last six academic periods (changes Pre and Post are statistically significant with a 95% of confidence level [excepting for 2-2020]). See self-efficacy scale by following: http://bit.ly/ING2030_self-efficacy.

Table 2. Self-efficacy changes according to Pre and Post surveys applied during the ING2030 course in the last six academic periods.

	1–2018 (N=267)	2–2018 (N=167)	1–2019 (N=266)	2–2019 (N=212)	1–2020 (N=206)	2–2020 (N=194)
Motivate a diverse group of people to work as a team	**0,3**	**0,3**	–0,2	0,2	**0,88**	**–0,5**
Study technologies and discover a new way to use them that could be practical	**0,4**	**0,6**	0,2	**0,4**	**0,77**	**–0,5**
Recognize a good business opportunity for international projection	**0,4**	**0,2**	0,3	**0,6**	**0,85**	0,1
Ask probing questions that stimulate other people to explore ideas	0	**0,6**	**0,4**	**0,5**	**0,44**	0
Select an alternative solution to a problem without having all the information necessary to solve it	**0,4**	**0,6**	0,3	**0,6**	**0,47**	**–0,4**
Design a prototype to understand how a new product or service works	**0,4**	**0,6**	**0,5**	**0,6**	**0,85**	–0,3
Design a business model that is scalable and replicable outside Chile	**1**	**1**	**0,6**	**0,7**	**1,55**	**0,4**
Write an entrepreneurship project description for competitive funds		**0,7**	**0,6**	**0,9**	**0,83**	0,1
Clearly describe a problem and its solution in Spanish in oral form	–0,1	**0,4**	0,2	**0,5**	**1,1**	–0,2
Start a technology-based entrepreneurship	0,3	**0,8**	0,3	**0,5**	**0,94**	0

Note: Self-efficacy differences were estimated by subtracting the average self-efficacy scores at the beginning (Pre) from the ones at the end (Post). These self-efficacy scores ranged from 0 to 10. The differences in bold are statistically significant at a 95% confidence level according to paired *t*-test students conducted in SPSS.

DISCUSSION AND CONCLUSIONS

Different lessons learned were captured from the findings described in the previous section. Across the last six academic periods, a significant percentage of students have perceived learning benefits from project feedback sessions and presentations that they undertook as a team. This finding resonates with current efforts from engineering programs to deliver entrepreneurial training through project- and team-based learning (Rae & Melton, 2017). In the case of PUC-Engineering, this type of training not only targets students who are interested in becoming entrepreneurs in the near future, but a wide diversity of learners who might explore diverse career paths. In that sense, the first lesson learned is that entrepreneurship education could be incorporated into project-based courses within the engineering core curriculum, offering all students the opportunity to identify entrepreneurship concepts and tactics as a team. Project-based courses provide learners with the opportunity to demonstrate the skills they have acquired throughout the development of an entrepreneurial endeavor, catalyzing the constructive integration of entrepreneurial skills and knowledge (Duval-Couetil et al., 2014).

With respect to other course teaching and assessment methods, the course coordination has made the sustained effort to include more working and mentoring sessions with the passage of time, reducing the number of instructors' and guests' lectures (see Figure 1). Consequently, students have perceived these types of sessions to be more beneficial in the last three semesters. According to Täks, Tynjälä, and Kukemelk (2016), engineering students value entrepreneurial learning opportunities that encourage them to integrate theory with practice. In that sense, courses such as ING2030 give students the responsibility over their learning by motivating them to acquire entrepreneurial skills and knowledge by themselves and develop a project within time constraints. Still, they expect their instructors to provide them with constant feedback to support their generation of ideas and their detection of good business opportunities (Täks et al., 2016). Thus, the second lesson learned is that teaching staff and experts should assume the role of learning facilitators by giving students timely feedback and guidance about their progress in their entrepreneurial projects. Furthermore, working and mentoring sessions should be used to emphasize social construction of learning, and during these sessions, teaching staff must play a mentoring role as they provide feedback and formatively assess students' learning.

Nonetheless, these findings must be interpreted with caution and a couple of limitations should be borne in mind. First, the ING2030 course is one of the many ways to deliver entrepreneurial training (Celis & Huang-Saad, 2015; Gilmartin et al., 2016), and findings are only representative for a specific context. Second, research on engineering entrepreneurship education is still an emerging field (Huang-Saad et al., 2020), and more studies are needed to build consensus on what is required to develop an entrepreneurial mindset among engineering students in different university settings. In order to address these limitations, more studies should systematically assess the self-efficacy gains and the learning benefits perceived by students from different entrepreneurial learning experiences (Purzer et al., 2016). In these lines, the data collected by the Engineering Education Unit from Pre- and Post-Surveys has provided course coordinators and instructors with information to reflect about curriculum and teaching practices at the end of every semester, motivating them to incorporate improvements from the perspective of students. Future work will triangulate these sources of evidence with students' performance in project deliverables and external evaluations, exploring the alignment between learners' perception and behavior.

In conclusion, we expect that this description of how a core course teaches engineering students about research, entrepreneurship and innovation will motivate other engineering education leaders and teaching staff to go beyond existing entrepreneurship majors and certificates. Designing entrepreneurial programs and courses for a wide diversity of learners is particularly important for engineering education programs in developed countries, where these type of learning experiences have recently started to emerge (Moreno et al., 2016), without necessarily providing information and studies on their effectiveness. Thus, more studies should be conducted to understand how entrepreneurship courses prepare engineering students for technology-based entrepreneurship and innovation, exploring self-efficacy shifts and learning benefits from course teaching and assessment strategies targeting a growing number of students.

ACKNOWLEDGEMENTS

This work was funded by CORFO under grant 14ENI2-26862. The authors would like to thank Francesca Anfossy for collaborating with this study as a research assistant, besides thanking the reviewers for their constructive suggestions.

REFERENCES

Assudani, R., & Kilbourne, L. (2014). Enabling entrepreneurial minds: Using appreciative inquiry as a pedagogical tool for uncovering self-awareness and for generating constructivist learning. *Journal of Entrepreneurship Education*, *17*(2), 52–62.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review*, 84(2), 191.

Beavers, A. S., Lounsbury, J. W., Richards, J. K., Huck, S. W., Skolits, G. J., & Esquivel, S. L. (2013). Practical Considerations for Using Exploratory Factor Analysis in Educational Research. *Practical Assessment, Research & Evaluation*, *18*(6), 1–13.

Bell, R., & Bell, H. (2020). Applying educational theory to develop a framework to support the delivery of experiential entrepreneurship education. *Journal of Small Business and Enterprise Development*, *27*(6), 987–1004. https://doi.org/10.1108/JSBED-01-2020-0012

Bonett, D. G., & Wright, T. A. (2015). Chronbach's alpha reliability: Interval estimation, hypothesis testing, and sample size planning. *Journal of Organizational Behavior*, *36*, 3–15. https://doi.org/10.1002/job

Celis, S., & Huang-Saad, A. (2015). Students Seeking Different Paths to Entrepreneurial Education. *Paper Presented at ASEE Annual Conference & Exposition*.

Celis, S., & Hilliger, I. (2016). Redesigning Engineering Education in Chile: How Selective Institutions Respond to an Ambitious National Reform. ASEE Annual Conference & Exhibition.

Chen, C. C., Greene, P. G., & Crick, A. (1998). Does entrepreneurial self-efficacy distinguish entrepreneurs from managers? *Journal of business venturing*, 13(4), 295-316.

Duval-Couetil, N., Kisenwether, E. C., Tranquillo, J., & Wheadon, J. (2014). Catalyzing the adoption of entrepreneurship education in engineering by aligning outcomes with ABET. *ASEE Annual Conference & Exhibition*.

Duval-Couetil, N., Shartrand, A., & Reed, T. (2016). The role of entrepreneurship program models and experiential activities on engineering student outcomes. *Advances in Engineering Education*, *5*(1), 1–27.

Ellwood, A. (2012). *The Dream Team: Hipster, Hacker, and Hustler*. Forbes.

Gilmartin, S. K., Shartrand, A., Chen, H. L., Estrada, C., & Sheppard, S. (2016). Investigating entrepreneurship program models in undergraduate engineering education. *The International journal of engineering education*, 32(5), 2048–2065..

Huang-Saad, A., Bodnar, C., & Carberry, A. (2020). Examining Current Practice in Engineering Entrepreneurship Education. *Entrepreneurship Education and Pedagogy*, *3*(1), 4–13. https://doi.org/10.1177/2515127419890828

Löbler, H., Maier, M., & Markgraf, D. (2019). Evaluating the Constructivist Approach in Entrepreneurship Education. *Research in Teacher Education*, *9*(2), 1–15. http://www.i-educate.eu/admin/Upload_Data/Resources/Evaluating the Contructivist Approach in entrepreneurship Education.pdf

Lucas, W. A., Cooper, S. Y., Ward, A., & Cave, F. (2006). Developing self-efficacy and entrepreneurial intent for technology entrepreneurship: the role of work experience. 3rd AGSE International Entrepreneurship Research Exchange, Auckland, 8–10.

Maresch, D., Harms, R., Kailer, N., & Wimmer-Wurm, B. (2016). The impact of entrepreneurship education on the entrepreneurial intention of students in science and engineering versus business studies university programs. *Technological Forecasting and Social Change*, *104*, 172–179. https://doi.org/10.1016/j.techfore.2015.11.006

Moreno, H. M., Moreno, R. de J., & Santa Ana, M. (2016). Las universidades públicas autónomas mexicanas : licenciaturas en ingeniería y su relación con el fomento académico de ser emprendedor Resumen Résumé. *In Vestigium Ire*, *10*(1), 118–138.

Odora, R. J. (2015). Integrating Product Design and Entrepreneurship Education: A Stimulant for Enterprising Design and Engineering Students in South Africa. *Procedia Technology*, *20*(July), 276–283. https://doi.org/10.1016/j.protcy.2015.07.044

Purzer, S., Fila, N., & Nataraja, K. (2016). Evaluation of Current Assessment Methods in Engineering Entrepreneurship Education. *Advances in Engineering Education*, *5*(1), 1–41.

Rae, D., & Melton, D. E. (2017). Developing an entrepreneurial mindset in US engineering education: an international view of the KEEN project. *The Journal of Engineering Entrepreneurship, 7*(3).

Raju, G. S., Kumar, N. S., & Ramgopal, N. C. (2015). Entrepreneurship and Innovation: A study on factors affecting engineering graduates towards entrepreneurship and innovation. *Journal of Engineering Education Transformations*, *1707*(Special Issues), 170–174.

Ryan, K., Gannon-Slater, N., & Culbertson, M. J. (2012). Improving Survey Methods With Cognitive Interviews in Small- and Medium-Scale Evaluations. *American Journal of Evaluation*, *33*(3), 414–430. https://doi.org/10.1177/1098214012441499

Sidhu, I., Singer, K., Suoranta, M., & Johnsson, C. (2014). Introducing Berkeley Method of Entrepreneurship - a game-based teaching approach. *74th Annual Meeting of the Academia of Management*.

Täks, M., Tynjälä, P., & Kukemelk, H. (2016). Engineering students' conceptions of entrepreneurial learning as part of their education. *European Journal of Engineering Education*, *41*(1), 53–69.

Tuckman, B. (1965). *Bruce Tuckman's Forming Storming Norming Performing Team Development Model*.

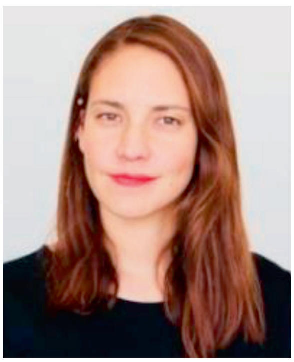
Walter, S. G., & Block, J. H. (2016). Outcomes of entrepreneurship education: An institutional perspective. *Journal of Business Venturing*, *31*(2), 216–233. https://doi.org/10.1016/j.jbusvent.2015.10.003

Wasserman, N. (2012). *The founder's dilemmas: Anticipating and avoiding the pitfalls that can sink a startup*. Princeton University Press.

Wright, M., Hmieleski, K. M., Siegel, D. S., & Ensley, M. D. (2007). *The Role of Human Capital in Technological Entrepreneurship*. *979*, 19–46. https://doi.org/10.1111/j.1540-6520.2010.00396.x

AUTHORS

Isabel Hilliger is the Associate Director for Assessment and Evaluation at the School of Engineering at Pontificia Universidad Católica de Chile (PUC-Chile). Isabel received a BEng and PhD in Engineering Sciences from PUC-Chile, and an MA in Policies, Organization and Leadership Studies from Stanford Graduate School of Education in U.S.A, Her research focuses on learning analytics tools for continuous improvement in higher education.



Constance Fleet is the Associate Director for Innovation at the School of Engineering at Pontificia Universidad Católica de Chile (PUC-Chile). Constance is Industrial Civil Engineer, diploma in Electrical Engineering from PUC-Chile. Her research focuses on innovation ecosystems and learning processes for developing entrepreneurial skills.

Constanza Melian is a sociologist and the Coordinator for Assessment and Evaluation at the School of Engineering at Pontificia Universidad Católica de Chile. She has developed quantitative and qualitative instruments to collect information in engineering education contexts, besides conducting research about engineering assessment.

Jorge Baier is an Associate Professor and the Associate Dean for Engineering Education of the School of Engineering at Pontificia Universidad Católica de Chile (PUC-Chile). He obtained his Ph.D. (Computer Science) from the University of Toronto. His research interests revolve around the areas of knowledge representation and reasoning, automated planning, and heuristic search and its relationship with machine learning.

Mar Pérez-Sanagustín is an Associate Professor at the Université Paul Sabatier Tolouse III (France), researcher at the Institute de Recherche Informatique de Tolouse (IRIT), and associate researcher at the Pontificia Universidad Católica de Chile (PUC). Her research interests include Self-Regulatory Learning processes in digital environments, Learning Analytics, blended learning, computer supported collaborative learning and engineering education.