2022 IEEE 28th International Conference on Engineering, Technology and Innovation (ICE/ITMC) & 31st International Association For Management of Technology (IAMOT) Joint Conference | 978-1-6654-8817-4/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICE/ITMC-IAMOT55089.2022.10033249

The e.DO Cube Hackathon – Transitioning to Graduate School

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***Abstract*—"Talent's ON e.DO Cube" Hackathon is an added value module, based on virtual hackathon setting, to promote sustained innovation and crowdsource solutions, to address real-life business topics and social issues. The hackathon served as a pivot-point from bachelor studies and challenged students to collaborate, in a time-stressed situation, for achieving a common result. Within a time-bound of 2 days competitive event, participants have to collaborate to build proofs of concept and minimum viable products for specific topics with innovative perspectives. This type of hackathon realized with e.DO Cube offered various advantages, among them the inclusivity (gender gap) and agility, it promotes multidisciplinary collaboration, and it is an innovative method to promote new ideas and original POCs (Proof of Concepts) within Manufacturing 4.0 scope. The proposal also includes a study done by POLIMI to measure the effectiveness of this specific pedagogical approach towards specific learning outcomes.**

Keywords—Hackathon, experiential learning, project-based learning

I. Introduction

With the growing need to empower innovators and encourage entrepreneurs to develop world-class solutions capable of meeting societal challenges the e.DO hackathon was created. The activity and competences described in this paper were targeted to empower top talents through cross-border and cross-sectorial mobility. The multi-disciplinary and diverse student cohort were selected based on their interest in innovation and entrepreneurship, and all expressed interest in entering manufacturing industrial domain.

Recognizing the needs and capabilities of the innovation community, the authors have chosen to focus on increasing knowledge and participation amongst bachelor students considering the transition to graduate studies. This targeted demographic was selected due to their eagerness to challenge the status quo as well as interest in spreading and advancing innovation. By facilitating the natural capabilities of the students and leveraging their academic knowledge the hackathon aims to foster easier graduate school transitions while creating a situation where unique education is both modern and responsive to the needs to students.

The 2021 EITM Master School was developed in response to a call to support partners and existing master programs create new courses in collaboration with industry, to test learning through a pedagogical approach and to measure the success of the methods towards student skill development.

The Talent's ON - e.DO Cube Hackathon aims at proposing a hackathon in a specific application field (it is to say manufacturing), with a provided application system (the e.DO Cube), to be used to train young talented students interested and motivated in learning the topics of industrial engineering and to challenge themselves in a collaborative and competitive environment.

A. Motivation

The Talent's ON – e.DO Cube Hackathon was conceived as one of the many activities meant to promote the EIT Manufacturing Master School to students who are on their way to the bachelor's graduation. The duration of the event was established to provide enough time for rapid development and proof of concept, and to encourage creativity [6]. For this reason, a 2-day event was organized by the joint forces of EIT Manufacturing, COMAU and Polytechnic University of Milan. The hackathon took place on November 25th-26th, online due to COVID-19 restrictions.

II. Research Approach

The hackathon was developed as an added value module, based on virtual hackathon setting, to promote sustained innovation and crowdsource solutions, to address real-life business topics and social issues [1,4,8]. Conceived as a concentrated and focused problem-solving effort where teams compete with each other to develop the best solution to the problem of the promoter. Within a time-bound 2-day competitive event, participants were challenged to collaborate on the development of two proofs of concept and a final minimum viable product for an industry established topic. To evaluate the learning and personal development gains from such an activity careful attention was paid to the tasks undertaken, and evaluation of the experiential results.

A. Hacakathon Competence Objectives

The objectives of the hackathon were the educational transition of bachelor students to graduate school. This objective required combined relational and focused tasks where students leveraged personal creativity to develop an industry suitable solution that leveraged robotics (Section II.B.). Life cycle thinking was established early on by the researchers as central a tenant of the hackathon, this was done since it requires engineers, designers, developers, consumers and business to consider the long-term ramifications of decisions. Based on this aim, the students were challenged to consider the UN *Sustainable development Goals Agenda 2030* when developing their solutions. The life cycle focus of this hackathon meant that students were forced to think beyond boundaries, navigate through opportunities and finally engender sustainable ideas.

This hackathon was realized by leveraging the Comau didactic robot e.DO Cube, which offered various advantages, among them the inclusivity (gender gap) and agility, it promotes multidisciplinary collaboration, and it is an innovative method to promote new ideas and original POCs (Proof of Concepts) within Manufacturing 4.0 scope.

B. Participant Selection

Focusing exclusively on bachelor students interested in transitioning to graduate studies required that they confront common challenges faced by other academic students. These challenges were presented to the students through a time-stressed situation, where collaboration would be critical to the achievement of a quality result.

Designed to engage bachelor students transitioning into their graduate studies, the event was developed to accommodate 50 manufacturing and industrial engineering students (or students with related interests) with 3-4 students per group [2]. Smaller teams were established so that the students would have clearer objectives, a higher level of participation, higher emphasis on quality and higher support for innovation than larger teams [5]. All of the participants were divided into teams, which were randomly formed by the organizers, to reduce the likelihood of people working exclusively with peoples they know and to foster soft skills related to team management and collaboration [7].

C. Hackathon Competence Assessment

The competences assessment carried out in parallel with the hackathon experience consisted of two different self-assessments, ex-ante and ex-post. This was accomplished by asking each student to self-evaluate their competences both before and after the hackathon, in order to assess any possible increase or decrease in their competence levels. In this section the methodology employed to carry out the competences assessment will be presented in detail.

Participants would be provided with a survey 3-5 days before the event to assess their perceived level of competence. The researchers focused on the following competences based on their industry relevance and life cycle focus: Industry 4.0, Manufacturing 4.0 and Digitalization:

- **Robotics:** is an interdisciplinary branch of computer science and engineering, that involves the design, construction, operation, and use of robots. The goal is to design machines that can help and assist humans.
- **Man-machine management:** enhance interactions and integration between machines and human labour.
- **Augmented solutions design:** capability of adequate application of augmented reality in the design process of the solution considered.
- **Augmented solutions** testing capability of adequate application of augmented reality in the testing process of the solution considered.
- **Step-by-step programming**: implementation of a set of step-by-step instructions that directs the computer to do the desired tasks and to produce the wanted results.
- **Visual programming and Coding**: intended as any programming language that lets users create programs by manipulating program elements graphically rather than by specifying them textually. It allows programming with visual expressions, spatial arrangements of text and graphic symbols.
- **Sustainable design**: design solutions in line with the Sustainable Development Goals Agenda 2030.
- **Proof of concept development**: effective development of a realization of a certain method or idea in order to demonstrate its feasibility, or a demonstration in principle with the aim of verifying that some concept or theory has practical potential.
- **Team collaboration**: Team collaboration is working together as a team on a project, process, or concept to achieve a better result than what could be obtained individually. It involves brainstorming, thinking creatively, offering unique skills, seeing the bigger picture, and meeting a common goal.
- **Team management**: ability of an individual or an organization to administer and coordinate a group of individuals to perform a task. Team management involves teamwork, communication, objective setting, and performance appraisals. Moreover, team management is the capability to identify problems and resolve conflicts within a team.

1) Self Evaluation Pre-Assessment

Participants were asked to self-evaluate their competences before and after the hackathon, in order to detect any possible increase or decrease in their competence levels through the learning process put in place during the hackathon experience. While self-evaluation has the potential for inherent bias, it was determined that the due to the hackathons focus on demonstrating and supporting graduate school transitions, self-evaluation was the most effective manner for evaluation.

TABLE 1 –AHP INPUT MATRIX

Vs.	Input Matrix						
	Knowledge	Autonomy	Complexity	Variability	Commitment	Proactivity	Innovation
Knowledge	1	0.142	0.000	0.000	0.333	0.333	0.500
Autonomy	7	1	2.000	1.000	6.000	3.000	6.000
Complexity	4	0.5	1	0.333	2.000	0.500	3.000
Variability	8	1	3	1	5.000	3.000	5.000
Commitment	3	0.17	0.5	0.200	1	0.200	0.500
Proactivity	3	0.33	2	0.330	5.000	1	3.000
Innovation	2	0.17	0.33	0.200	2.000	0.330	1
Total	28	3.309	9.083	3.191	21.333	8.366	17.000

As shown in Table 1, it is not easy to ask a quantitative determination of a specific competence, as it could be subjective and biased. For this reason, through industry partner input, literature and academic experience, 7 different dimensions of a competence have been identified: (1) Technical knowledge, (2) Autonomy, (3) Complexity management, (4) Variability Management, (5) Commitment, (6) Proactivity, (7) Innovation.

Based on the criteria established in Table 1, the researchers isolated the most critical competences (Section III) and evaluated the participants proficiency accordingly:

- 0 = None: You are aware of information, ideas and situations related to the competence but have not yet had an opportunity to practice it.
- 1 = Limited: You've just started to find opportunities to work on this competence. You make initial assessments of what is expected of your role. Your understanding of the impact of your actions is limited. Your actions meet some performance expectations, but you know that you could improve.
- 2 = Basic: You've demonstrated this competence and think about how to develop it further. You engage in conversations with others about how you can best contribute and how this competence is important.
- 3 = Proficient: Your actions usually meet the expectations of yourself and others. You look for opportunities to apply this competence in other areas of your life.
- 4 = Advanced: You've reached your overall goals and often think about opportunities to use and practice this competence. You consistently meet expectations. You consider your learning and appreciate the significance of this competence in relationship to your experiences. Demonstrated high quality work with a positive impact.
- 5 = Expert: You have an overall mastery of this competence. You understand and demonstrate it in all areas of your life. You are considered as a role model by others and regularly exceed expectations. Your work is of a very high or exceptional quality and has significant impact.

Once all the evaluations were collected, the level of each competence for each of the participants before the hackathon, was calculated through Formula 1:

$$Competency\ Level_i = \sum_{j=1}^{N} P_{ij} * p_j \qquad (1)$$

With:
i, related to the different competences;
j, related to the different criteria;
Pij = value of competency i according to the criterion j, given from the self-evaluation;
pj = weight of criterion j, as shown in Table 1;
N = total number of criteria.

2) Self Evaluation Pre-Assessment

The day after the hackathon, participants were asked to complete the same survey (pre-assessment), in order to identify any progress that might have occurred through the performance in the event.

Moreover, they would be asked to self-evaluate their outcome in order to make a small group assessment, comparing their self-evaluation with the ones made by the official jurors of the challenge. The evaluation of the outcome of the challenge was made across 5 different dimensions, combining industry evaluation and industry assessment:

1. **Quality**: What is the added value of your solution for the target you selected?
2. **Originality**: Does your solution have some elements of innovation?
3. **Feasibility**: Is the implementation of your solution feasible in the context?
4. **Sustainability**: Is your solution in line with any Sustainable Development Goals of 2030 ONU Agenda?
5. **Communication**: Was your solution properly pitched? Was the aim of your solution effectively conveyed?

III. E.DO CUBE HACKATHON DESCRIPTION

The hackathon styled program was utilized due to its ability to facilitate an amazing educational experience for students to engaged with their peers. This hackathon provided a unique opportunity for students to develop their skills from the comfort of home and begin challenging themselves for the rigors of graduate school [1,4]. In conjunction with the hackathon partners the e.DO cube technology student teams were challenged to 3D print the POC of an innovative product, to be conceived in line with the Sustainable development Goals Agenda 2030.

A. Undertakings

In preparation for the event the participant teams were challenged to imagine and design a technical improvement or a technological application for e.Do Cube, with the following objectives in mind:

- Conceive and develop a POC or MVP
- Define areas of innovation and addressees
- Support the development of an entrepreneurial mindset
- Implement team dynamics, problem solving and critical thinking
- Understand the evolution of the man/machine relationship within industry 4.0 and digital transformation
- Use physics and mathematics as elements of creation and innovation.

The aim of the event was to challenge students on the topic of Industry 4.0 and digitalization, through the utilization of the e.DO cube technology provided by COMAU.

B. Participant Tasks

Each team had the opportunity to use their creativity and skills to design and develop a product, defining the final users and the scope of use/application. Moreover, through the adoption of the e.DO cube technology teams were also asked to 3D-print the POC of their innovative product, to be conceived in line with the Sustainable development Goals Agenda 2030 (Section II-A).

According to the hackathon objectives the participant teams were be asked to imagine and design a technical improvement or technological application for the e.Do Cube and exhibit their ideas with a 3-minute video. E.Do Cube is an educational robot, versatile and easy to use, which will be used to shape an online challenge to dive and lure participants towards the Industry 4.0 and its resolution. Additionally, further to the requests of the challenge, the bachelor student teams were encouraged to develop an entrepreneurial mindset, without neglecting their creativity at the same time [3]. The outcome of the challenge was a three-minutes video where the students were required to present a comprehensive solution. The teams with the highest overall score would then be awarded by the hackathon facilitators during a ceremony in recognition of the work, effort and diligence leveraged.

C. *Implementation*

The ON – e.DO Cube Hackathon was held virtually due to Covid-19 which required the facilitators/partners to strictly monitor and track the timing and the progress of the project. Following a set of scheduled tasks, and priority's, all stakeholders were aware of the tasks and their deadlines. A basic Gantt chart was provided to support the start and end times/dates of the project and intermediate milestones if any.

Focusing on the EIT FLAGSHIP "Digital & collaborative solutions for innovative manufacturing ecosystems." This approach to problem solving utilized a gamification layer on top of our online hackathon, to further motivate and reward students for being innovative while being creative and staying aligned with the core request of the challenge. The challenge, and activities (tasks), proposed to the participants over the two days, aimed to stimulate the innovation culture and foster ideas about innovation skills and competencies (which are described in Section 3).

D. *Evaluation*

The evaluation of the concepts would follow a traditional hackathon approach, combining both academia and industry to evaluate the effectiveness, ingenuity, and completeness of the student project outcomes. After a careful evaluation of each concept, judges, the evaluators scored the final designs and provided review sessions to discuss the attributes and areas of excellence/improvement for each team. Thanks to the competences of the facilitators' team, the challenge has further established the idea-sharing, effective collaboration, and creativeness, as well as implementing team dynamics, problem solving and critical thinking. Each member of one of winning teams would receive an e.DO Cube robot to support the continued advancement of their creativity.

IV. E.DO CUBE HACKATHON OUTCOMES

The hackathon provided a dymnamic way to engage students during constructive learning processes and as a means to make them express their creativity by thinking out of the box and approaching topics related to their field of study from different perspectives. Out of a total of 18 participants, divided into 6 teams, 15 answers to the pre and post surveys were received. The level of competence detected pre vs. post hackathon was evaluated according to the method presented in Section III.

A. *Pre Self-Assessment*

The normalized values (Table 2) are presented for the input criteria (Section III).

TABLE 2 – NORMALIZED AHP SCORES IDENTIFIED FOT THE MOST IMPORTANT CRITERIA

Vs.	Normalized Matrix								
	Knowledge	Autonomy	Complexity	Variability	Commitment	Proactivity	Innovation	**Average**	**C. Measures**
Knowledge	0.04	0.04	0.03	0.04	0.02	0.04	0.03	0.03	7.30
Autonomy	0.25	0.30	0.22	0.31	0.28	0.36	0.32	0.29	7.43
Complexity	0.14	0.15	0.11	0.10	0.09	0.06	0.16	0.12	7.24
Variability	0.29	0.30	0.33	0.31	0.23	0.36	0.26	0.30	7.40
Commitment	0.11	0.05	0.06	0.06	0.05	0.02	0.03	0.05	7.08
Proactivity	0.11	0.10	0.22	0.10	0.23	0.12	0.16	0.15	7.49
Innovation	0.07	0.05	0.04	0.06	0.09	0.04	0.05	0.06	7.33
Total	1.0	1.0	1.0	1.0	1.0	1.0	1.0		

According to the average normalized value for each criteria, it three criteria areas of were prioritized:

1. Variability Management: intended as your capability to cope with the intrinsic variability of a specific task, dealing with its unpredictability. E.g., While programming, you could find yourself facing problems you hadn't forecast or the unpredictability of a variable not acting like you thought, are you capable to cope with it?

2. Autonomy: intended as your ability to perform the task you are assigned to without any external help or guidance. E.g., I can design a product according to sustainable principles without the help or guidance from anybody.

3. Proactivity: intended as your tendency and inclination to do, driven by interest and willingness to learn. E.g., I'm so interested in robotics, I spend time making extra-reading on the topic and proposing myself for tasks beyond my duties.

Once identified, a second AHP was developed to evaluate the criteria and establish their individualized weight. The scores given in the second AHP are shown in Table 3.

TABLE 3 –AHP INPUT AND NORMALIZED MATRIX AHP FOR THE DETERMINATION OF THE WEIGHTS OF THE THREE CRITERIA

Vs.	**Input Matrix**				
	Variability	**Autonomy**	**Proactivity**	**Average**	**C. Measures**
Variability	1	0.20	0.33	N/A	N/A
Autonomy	5.00	1	2	N/A	N/A
Proactivity	3.00	0.50	1	N/A	N/A
Total	9.00	1.70	3.33		
	Normalized Matrix				
Vs.	**Variability**	**Autonomy**	**Proactivity**	**Average**	**C. Measures**
Variability	0.111	0.117	0.100	0.1096	3.0012
Autonomy	0.555	0.588	0.600	0.5813	3.0064
Proactivity	0.333	0.294	0.300	0.3092	3.0035
Total	1.0	1.0	1.0		

Additionally, Table 4 below shows the weights assigned to the three criteria observed.

TABLE 4 – WEIGHTS OF THE THREE CRITERIA SELECTED TO DESCRIBE A COMPETENCE

COMPETENCE	WEIGHT
VARIABILITY	0.11
AUTONOMY	0.58
PROACTIVITY	0.31

B. *Post Self-Assessment*

The normalized post values (Table 5) are presented according to the prioritized input criteria identified in Table 2 and evaluated according to the weights established in Table 4. The survey sent to the participants for the Post Self-assessment was evaluated upon return based on Formula 1.

TABLE 5 - EVALUATION SCALE FOR THE ASSESSMENT OF THE FINAL OUTCOME

EVALUATION SCALE	
NULL	0
INSUFFICIENT	1
SUFFICIENT	2
GOOD	3
REMARKABLE	4
OUTSTANDING	5

C. *Comparision of Pre vs. Post Self-Assessment*

Comparing the pre and post assessment was accomplished by evaluating if there was increase in the level of a specific competence, or a decrease in the level of a specific competence. As illustrated in the Fig. 1 most of the participants expressed a very low level of initial competences (around 1 or 0), both for hard and soft skills. In this regard, the soft skills were not easy to be developed due to the online modality, and this is reflected in the evaluations, usually in line between pre and post conditions. However, in general the scores of the participants showed a very high interest in the topics of the challenge and in this new way of learning, a bit distant from the canonical one of universities, relying on practice and on learning from experience and mistakes.

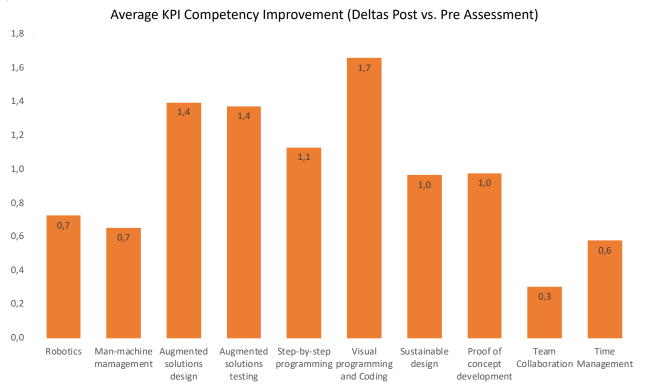

Fig. 1. Average KPI Competency Comparison (Pre vs. Post)

1) *Variability Competence Outcomes*

In Fig. 2 the values of the KPIs calculated for each participant were averaged to determine the effect of the hackathon in respect to KPI-Variability. Conditional formatting was utilized to identify the entity of the progress. While not illustrated in the average values, this allowed for the identification of instances where participants showed no progress or a lower level of competence after the hackathon experience. Contrarily to what was expected, some participants manifested a decrease of the level of the competences identified during the hackathon experience. As a matter of fact, 2 participants claimed a non-adequate learning process for most of the competences interested.

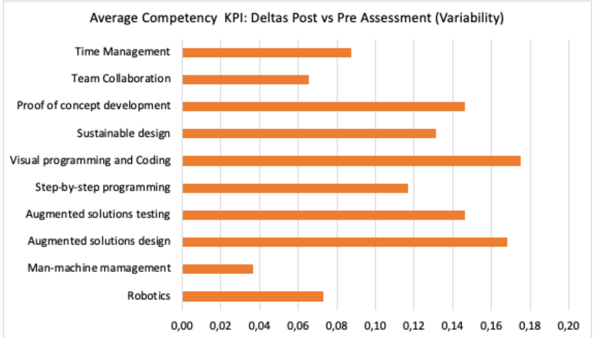

Fig. 2. Average KPI-Variability Competency Comparison (Pre vs. Post)

2) *Autonomy Competence Outcomes*

In Fig. 3 the values of the KPIs calculated for each participant were again averaged to determine the effect of the hackathon in respect to KPI-Autonomy. Conditional formatting was utilized to identify the entity of the progress. experience. In respect to this KPI as illustrated in the graph the overall competence was considerably higher than that measured in Variability. Based on the outcomes observed the students had a considerable increase in their level of competences.

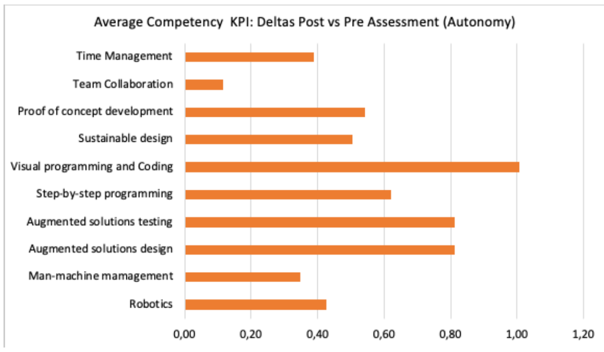

Fig. 3. Average KPI-Autonomy Competency Comparison (Pre vs. Post)

3) *Proactivity Competence Outcomes*

In Fig. 4 the conditional values of the KPI-Proactivity were calculated. In respect to this KPI the participants presented higher evaluations than the other two KPI's, showing a high commitment and interest in the disciplines object of the challenge. On the other hand, expressed a lack of autonomy to perform the task required without an external guidance, from one of their teammates or of the tutors available for external help during the whole event.

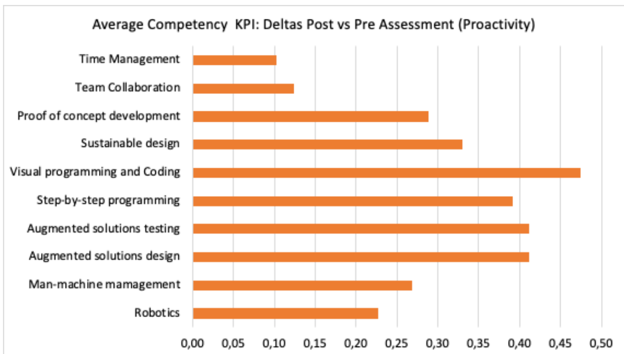

Fig. 4. Average KPI-Proactivity Competency Comparison (Pre vs. Post)

D. General Discussion

By asking participants to self-evaluate the final outcome they came up with, following the same instructions that were given to the official jurors of the challenge. Also in this case, the KPI analysed was the difference between the team members' evaluation (obtained as a simple average of the evaluations provided by each team member) and the jurors' evaluation (obtained as a simple average of the evaluations provided by each juror).

V. Conclusion and Future Work

The Hackathon structure allowed the participants to learn about Robotics and Industry 4.0, giving them the possibility to use and program an actual robotic arm. With the use of e.DO Cube, the Comau's educational 6-axis robot, the participants have experimented the evolution of the man/machine relationship and digital transformation.

Being strictly related to Innovation skills and competencies; Intellectual transforming skills and competencies; Leadership skills and competencies, this hackathon aimed to push actionable ideas through POCs, incentivize the design of strategic product concepts and process improvements. It has indeed been thought to provide a great way to inspire team working, incentive leadership, teambuilding, promote creativity, collaboration, and innovative thinking.

Certainly, the participants, who have been duly supported and lead to establish a process of creative ideation, have presented valuable new ideas like the Biodegradable Plastic for 3D printing in the Automotive Industry, the Eco water saver (ECOWS), or the Biodegradable 3D printed circuit board or the Flexible platform for Sustainable 3D printing food production.

The experience gained with the hackathon organization and delivery might be exploited in the future to offer a similar activity for the next cohorts of the Master students and/or to create new educational experiences for external students. IT is acknowledged that the 15-participant sample size is limited. Thus, in future, work will be undertaken to increase the number of participants (next cohort), to better facilitate the development of new concepts/products that can be brought to the market and support the launch of start-ups.

For the future, when the Covid-19 becomes less impactful in-person meetings the organizer intends to coordinate a follow-up event in presence. It is expected that the face-to-face modality would favour networking and teambuilding in an important way.

Lastly, an individual meeting has been planned with each team at the end of February during which participants will be able to obtain the score of their POC. Additionally, the authors will share with them any additional comments concerning their ideas and how they were presented. At this time participants will also be asked to provide their comments and suggestions about the experience itself and impact on their studies/life if any.

Acknowledgment

This project was made possible by direct funding from EIT Manufacturing (EITM).

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