Rethinking Entrepreneurial Education: The Role of Digital Technologies to Assess Entrepreneurial Self-Efficacy and Intention of STEM Students

Simonetta Primario, Pierluigi Rippa, and Giustina Secundo

***Abstract*—The COVID-19 pandemic imposed restrictions and social distancing requirements that limited face-to-face education. However, the challenge of continuing studies, albeit in an online environment, promoted the redesign of teaching models, thanks to the availability of digital technologies such as MOOCs, gamification, and digital platforms. The aim of this study is to analyze if students' entrepreneurial self-efficacy and intention can be achieved through an online designed and delivered entrepreneurial course, as in face-to-face entrepreneurial education, and whether digital technologies are helpful in pursuing this goal. Data from a sample of 210 engineering students enrolled in an online entrepreneurship course having a duration of 16 weeks revealed a positive impact of digital technologies adoption on students' self-efficacy and intention in launching a novel entrepreneurial venture. Practical implications concern insights about entrepreneurship education programs' learning strategies that need to be redesigned, with the adoption of ad hoc digital tools to support projects and business plan development. Finally, the study proposes managerial and policy implications for improving the inclusion of digital tools for enhancing University students' entrepreneurship education in the digital era.**

***Index Terms*—Academic entrepreneurship, digital technology, entrepreneurial intention, entrepreneurial self-efficacy, entrepreneurship education (EE), Italy, online education, STEM.**

I. Introduction

THE year 2020 will always be recognized as the year of COVID-19 (Corona Virus Disease 2019), the global health crisis that generated a disruptive impact on most economic and social activities, including schools and universities [1], [2]. This crisis entirely affected universities, considering the national regulations defined to undertake urgent solutions to reconfigure traditional teaching models using digital technologies [3]. Restrictions on mass gatherings and social distancing requirements [4], [5], [6] have limited class teaching, resulting in a quick, massive shift to online teaching for University students [5], [7], [8]. The crisis offered a valuable occasion to reflect on, design, and implement new education processes that leverage digital technologies' potential also in action based and experience based courses as entrepreneurship education (EE) [3], [8], [9].

Over the past two decades, state policies and industrial associations have challenged engineering educators to expand future engineers' training beyond technical competencies to the broader domain of professional skills development, with one key aspect being engineering leadership [10] and EE [8], [9], [11], [12], [13]. With this aim, recently scholars underlined the increasing importance for engineering students of EE as a high growth field [8], [11], [14], [15], [16], [17], [18] although the first studies appeared in the early 2000s [19], [20]. The development of engineering students' entrepreneurial mindset is considered a strategic tool for economic and social growth in several economies [18], [21], [22], [23]. The creation of an entrepreneurship culture is also among Italian Universities' strategic priorities. The OECD Leaders Survey 2019 [24] positions the creation of an entrepreneurial mindset in students at the third place of Italian Universities' strategic objectives (with 39% of preferences) [8]. Five key elements to be considered when planning entrepreneurial education are introspection, entrepreneurial intention studies, pedagogy, entrepreneurial learning, evaluation studies exploring outcomes, and effectiveness of entrepreneurial education [15]. The need for independence is the key factor in future engineers' entrepreneurial intent and confirms EE's positive contribution on their entrepreneurial intentions [11], [25], [26].

Despite the abundance of studies on EE, according to Fayolle et al. [11] a research gap exists whether entrepreneurship could be taught to engineering university students through the adoption of digital tools and technologies. Whereas scholars analyzed the crucial role of digital platform and tools for education [27], [28], [29], few studies deepened how these technologies could provide a strategic support in accomplishing typical "action based" and "experienced based" university courses such as EE [8], [9], [30]. Moreover, also the particular situation generated by the health emergency represents a valuable case to test how digital technologies can be adopted to design and deliver EE processes [5]. The adoption of digital technologies is strategic for creating entrepreneurially equipped students [31], also in consequence of European countries' need to accomplish the

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Digital Education Action Plan (European Commission, 2018). Accordingly, moving from the above premises and research gap this article ought to provide an answer to the question how entrepreneurship can be taught online and whether digital technologies can support experiential learning in online environment promoting engineering students' entrepreneurial self-efficacy. Our approach is based on a learning experience in a master class of 210 University engineering students. Students attended a mandatory entrepreneurship course fully rethought to be provided online during the first semester of academic year 2020–21. The course's teacher adopted a proprietary platform for blended learning in EE. Moving from the analysis of the main challenges the pandemic generated for the Universities all over the world, we analyze and discuss the process of redesigning an entrepreneurial learning program by leveraging digital technologies. Findings propose a new approach to entrepreneurial storytelling, pitching, and business planning and development of EE for engineering students through digital technologies. Implication for theory provide contributions to digital enabled EE. At practitioner and policy level, it offers insights on redesigning entrepreneurship university programs to effectively address the arising emergency of on line education.

The remaining article is structured as follows. Section II describes the theoretical framework and research hypotheses; in Section III, the methodology is described along with findings. Section IV discusses the findings and Section VI concludes the paper. Implications for theory and practices are provided.

II. Theoretical Framework and Research Hypotheses

Conventional wisdom has always led to thinking that EE increases the intention to start a business [32]. For a couple of decades, professors asked themselves why and how to teach students to be entrepreneurs [33].

The COVID-19 outbreak poses a significant challenge to EE, as the learning process is mainly based on experiential courses [5], [31], [34], [35], [36]. It is accepted that students in engineering, science, and technology majors should be exposed to EE, encouraging their inclinations and intentions to act enterprisingly and/or entrepreneurially through the use of dedicated teaching models [11], [25], [26], [37]. According to Welter and Lasch [38], universities have a growing trend to institutionalize EE by creating dedicated infrastructures and centers for realizing progressive accumulation of knowledge for entrepreneurial learning [39]. Besides, there is a tendency to provide EE to engineering, computer science, and life sciences University students who are generally more inclined to produce innovations [26].

Several studies indicate that entrepreneurship should be included in the engineering curriculum to develop an entrepreneurial mindset and intentions [25], [37], [40]. The entrepreneurial mindset represents competence in helping members of society, students at all levels of education, young entrepreneurs, and start-up operators to be creative and confident in whatever they undertake to cope with business uncertainty, ambiguity, and complexity [41].

The EE field faced an evolutionary path from the beginning of its history during the 80 s when the debate revolving around entrepreneurial curriculum content was devoted mainly to business and management students, to our days when the Covid-19 emergency forced universities all over the world to reconfigure their programs. With this aim, the digital revolution has opened fascinating opportunities for innovating EE [26], [42], [43], [44]. The adoption of digital technologies is strategic for creating entrepreneurially equipped students [31], [45]. Consequently, European countries need to accomplish the Digital Education Action Plan. Technologies' rapid development has profoundly changed EE, in which MOOC providers, incubators, and accelerators provide ad hoc content to individuals and teams who undertake the entrepreneurial process [5], [46]. EE can be delivered online after the complete redesign of the entrepreneurial learning strategy, by the use of different digital education platforms, by the reuse of digital contents, and integration of innovative complementary technologies, with the resulting extensive use of online courses, simulators, interactive whiteboards, projectors, and three-dimensional printers [22], [47], [48]. This introduces changes and innovation in the content delivery, content aggregation, people collaboration, interactive discussion, information sharing, idea development and validation, access to resources, project development, simulation, and prototyping also with reference to the academic entrepreneurship process [3].

According to Nambisan [49], the digital technologies sustaining entrepreneurship and also education for entrepreneurship can be divided into: "digital artifact" able to extend the competence development process in a virtual space; "digital infrastructure," sets of distributed tools and systems that offer communication and collaboration, or "digital platform," specific software and interfaces allow integration with external recipients of data, digital artifacts, and suppliers of contents and services. Digital technologies support the traditional EE models [50] since they contribute to enhancing communications among the ecosystem actors involved in the entrepreneurial development processes [8].

The nature of EE programs requires a diversified set of learning approaches and teaching tools when addressing engineering students' educational needs. It is challenging for either engineers and scientists who lack managerial skills or management students who lack an engineer or science-oriented background [51]. EE delivery is typically characterized by experiential learning model such as simulations, role paly through the redesign of real life experience in the learning process. The entrepreneurial learning strategy is experiencing a flourishing period due to the availability of digital technologies, that can offer more advanced support to EE through the possibility to access an online community to develop and tune potential business ideas [52] and to engage in innovative entrepreneurial learning experiences supported by emerging digital technologies [45]. Experiential learning is the focus of entrepreneurial educators' interest, intending to assess and measure the impact of EE [53], as we are leaving a learner-centered period with a strong emphasis on the interplay between learners and practitioners. Adopting digital technologies in EE can drive relevant changes in the students'

experiences in terms of online collaboration, online engagement, and teamwork satisfaction [54], [55], [56].

Our investigation is prompted by the need to understand if online EE delivery approach favors the entrepreneurial learning process providing graduates students' entrepreneurial self-efficacy and intention so transforming them into individuals who have life skills [57]. Still few studies analyze the impact of digital technologies on online entrepreneurial education processes [8], [30].

A. Online Entrepreneurship Education and Students' Entrepreneurial Self-Efficacy

A person's belief in performing a specific task based on his capability is called "self-efficacy," and is a critical element in social learning theory [58], [59]. The ability to convert personal skills into a chosen outcome is based on the individual's self-perception in a task and specific domain. Entrepreneurial self-efficacy (ESE) is related to perceived capabilities to manage innovation, risk, leadership. ESE is defined as the "strength of a person's belief that he or she is capable of successfully performing the various roles and tasks of entrepreneurship" [60, p. 295]. Different educational approaches have been shown effective to improve the level of entrepreneurial self-efficacy in students from different disciplines. Business plan development, business games, and true business simulation can significantly impact ESE. Digital technologies ought to be an opportunity to develop such capabilities quickly, even if online. Augmented reality, additive manufacturing, social networks, are some examples of how technologies are revolutionizing aspects related to learning, and how entrepreneurial learning methods are changing. Watts and Wray [61] tested a simulation software that in the field of pedagogy makes students find a high consensus, or web-based systems helping students in a British university demonstrating how they were able to significantly improve their learning experience [62]. Smith and Pathon [63] implemented a social network technologies to enable learning and knowledge acquisition demonstrating how it was greater than the sum of the parts. Mancha and Shankaranarayanan [64] built a model linking four individual characteristics such as entrepreneurial orientation, digital literacy, entrepreneurial self-efficacy, and digital technology self-efficacy to digital innovativeness. They reveal how two antecedents of individual digital innovativeness linked to personal beliefs of competency are correlated to an individual's digital innovativeness. Unfortunately, none of these studies explore a fully online immersive EE program, thus the first hypothesis is as follows:

> *Hp 1:* The adoption of digital technologies in EE delivered online will favor students' entrepreneurial self-efficacy.

B. EE and Engineering Students' Entrepreneurial Intention

In the last three decades, research related to EE provided several models to study students' entrepreneurial behavior. Among the many theoretical frameworks proposed, intention-based models are undoubtedly the most popular. The basic argument underlying the intention-based models is that entrepreneurship is a planned, volitional, and controlled behavior that is inherently intentional rather than instinctive. According to this point of view, individuals develop entrepreneurial intentions before initiating actions to create a new venture [65], [66], [67], [68], [69].

Several variables influence a student's decision to start a business: intensity of entrepreneurial education [22], [70], the presence of a supportive environment [71], [72], parents' entrepreneurship experiences [71], personal behaviors to start new businesses [73], and personal attitudes and traits to invest in new ventures [32], [74]. A more experiential and student-centered approach is considered to be central in the modern vision of project education, and participating in an entrepreneurship program could inspire students to take the entrepreneurial path.

Studies based on the theory of planned behavior (TPB), Ajzen [75] confirm a relationship between EE and entrepreneurial intention [32], [76], [77], [78], [79]. Specifically, many studies confirm EE's positive contribution to engineering students' entrepreneurial intentions [25], [80], [81], [82]. Urbano et al. [83] suggest that EE positively affects university students' probability of becoming employer entrepreneurs.

Significant studies argue that a technology-based education may improve students' entrepreneurial intention [84], [85]. Mayer et al. [84] tested the effect of a game-base EE, founding how previous experiences and motivations affect the entrepreneurship intention after the training. This experiment was delivered in a physical classroom, thus it is difficult to exploit the results in an online environment. Fellnhofer [85], based on the results of analysis run in a physical classroom with 41 students, founded a positive impact of key game elements in EE in terms on attitudes and intentions. At the same time, Fellnhofer called for a more in-depth analysis of a web-based teaching methods for EE.

The introduction of digital technologies helps entrepreneurial curricula in universities to include project-based learning, highlighting the importance of valuable results as well as theoretical applications [86]. Thus, we speculate that digital technologies enable the student to develop entrepreneurial skills and creative ideas and provide other knowledge needed for entrepreneurship. The teamwork enabled by these technologies favors creativity, collaboration, and interaction among students that could positively affect their attitude toward behavior both at instrumental and affective levels [66].

The Ajzen model identifies a second precursor of intention, the subjective norms (SN). This construct is defined as the sum of the products of individuals' "normative beliefs" about the perceived opinion of reference people (e.g., family, closest friends, other important people), with the "motivations to comply" (the extent to which the individual cares about those perceived opinions). Unlike most authors [87], we choose to test even for the effect of participation in courses supported by digital technologies on the perception of how socially desirable it might be to start a new business. Studies analyzing the impact of digital technologies on entrepreneurial education adopt social media as informal and formal learning [88], revealing an increasing student engagement [89] and satisfaction [90]. Participants to entrepreneurial education exposition communicate with each

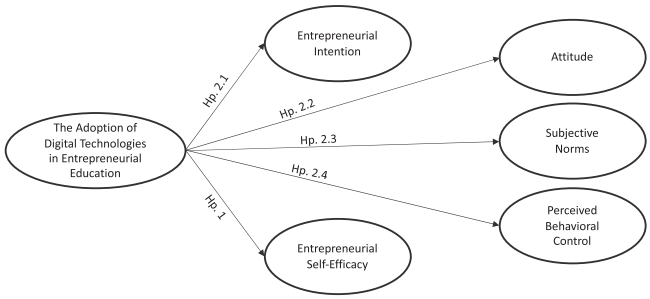

Fig. 1. Research hypotheses.

other through social media, showing their life (using Youtube or Instagram) and sharing work experiences (e.g., Linkedin). The aim of the learners is to build a social network and human relations [91], [92].

The idea behind this choice is that building collaborative, open, and interactive environments help students feel part of a group in which risk, failure, and the desire to succeed are accepted, discussed, and valued. The more students perceive that they are in an environment of shared entrepreneurial values, the greater their intention to start a new business. Therefore, all the tools to support this construct should be desired in academic pathways that are sensitive to the topic.

Finally, perceived behavioral control (PBC) is an antecedent defined as a "person's perception of the ease or difficulty of performing the behavior of interest" [75, p. 183].

Nowadays, people increasingly rely on digital tools to perform "how-to" search or look for direct help to carry out tasks [93]. While some of this help is obtained through economic transactions, there is no shortage of free advice and tools online. This is even more true when team members resort to a common space where they help each other in the absence of any direct market incentive. One of the most critical functions of nonmarket-based digital technologies is to provide resources for action [94] in terms of information, advice, and even logistic support. Following these perspectives, we expect digital technology use to provide an environment in which students can become more confident in their means and less concerned about the difficulties and resources needed to act.

Based on these premises, we put forward and tested the following hypothesis.

Hp 2.1: The adoption of digital technologies in EE delivered online will favor students' entrepreneurial intention.

Hp 2.2: The adoption of digital technologies in EE delivered online will increase the degree to which starting a new business is positively valued (Attitude).

Hp 2.3: The adoption of digital technologies in EE delivered online will increase the degree to which starting a new business is perceived as socially acceptable (SNs).

Hp 2.4: The adoption of digital technologies in EE delivered online will increase the degree to which starting a new business is perceived as more feasible (PBC).

Fig. 1 synthetize the research hypothesis tested.

In the following section, we tested the hypothesis on a sample of engineering students exposed in an online entrepreneurship course with a format redesigned through the adoption of a digital tool. The aim is to verify the level of performance achieved in term of self-efficacy and entrepreneurial intention when students are exposed in an online entrepreneurship course.

III. Methodology

According to Cohen et al. [95], we applied a two-stage quali-quantitative analysis to assess the improvement of Engineering students' expertise and capabilities, triggered by using digital technologies to support their involvement in EE.

A one group pretest-post-test experimental design allowed us to account for differences between pretest and post-test scores by reference to the effects of an experimental manipulation (i.e., a ten-week curriculum project) designed to increase the inclination of students involved in the experiment. Therefore, the final purpose of this study was to understand how students perceive EE and which individual factors affect engineering faculties' research outputs.

Improvement of Engineering students' expertise and capabilities is triggered by using digital technologies to support their involvement in Entrepreneurship Education, through a two-stage quali-quantitative analysis.

A. EE Online Course Description

The "Strategy and Entrepreneurship" course constituted the basis for analyzing digital technologies' role in supporting an online EE program devoted to Engineering University students and how it addresses students' entrepreneurial self-efficacy and intentions.

The course was fully designed to be entirely delivered online in 2020 due to the restrictions imposed by national law for the Covid-19 pandemic. For this reason, the typical structure of the course has been reengineered to meet the requirements of the online organization of EE [8]. The EE course design was intended to create a professional and interactive and experiential learning environment to keep the students' motivations high and increase their willingness to have an entrepreneurial career. The program was divided into the following three modules.

1) Theoretical module, giving students the basis of the entrepreneurial mindset (highlighting the main models adopted to create new businesses). It starts from the opportunity source to the business model definition, highlighting competitive and innovative strategy options. It covers all the phases of a business plan development (market plan, organizational plan, operative plan, financials).
2) Professionals module, with interactive seminars with firms, startups, managers from incubators, institutional and private investors, business angels and managers from governmental departments. The sequence of the seminars follows a typical lifecycle journey of a company.
3) Business plan lab module, in which students were stimulated to create their own business project supported by PEAQS, a digital platform that help students simulate the market launch of their business idea.

TABLE I
STRUCTURE OF PEAQS

	Module/Phase	Description
Phase of PEAQS Experience as Entrepreneurs	Concept invention	Students describe their business idea and the composition of team founders.
	Business Case Implementation	Students make a Market Analysis to identify competitors, strengths, weaknesses, threats, and market size.
	Product Description	Students present technical details of product/service offered using slides, papers, and video.
	Get to Market	Students identify the business model, cost structure, market strategy, and communication plan for their business idea.

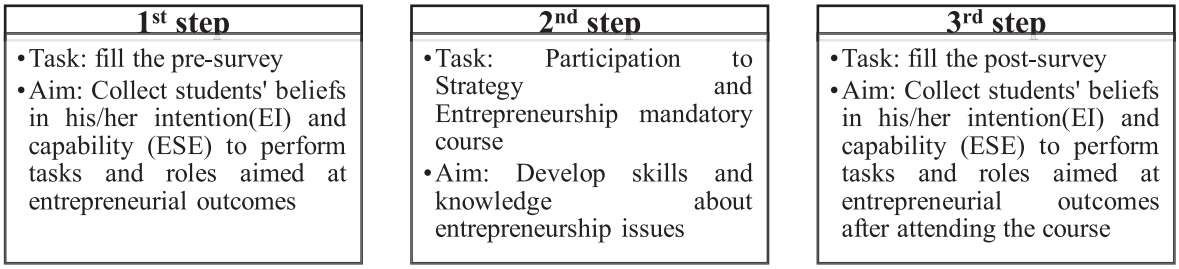

Fig. 2. Proposed procedures.

Students are asked to create groups and propose a business idea. The lab was supported by PEAQS, a high-level learning game platform that combines a project development process with a virtual stock market engine for real-time valuation and peer feedback. PEAQS (see Table I) comprise a funnel of feature-specific, product development and get-to-market strategy and communication planning activities. The project is then presented on a stock market simulation platform where each student also acts as an individual investor. The final result is a stock market of ready-to-go business plans, entirely ranked in popularity under the well-informed scrutiny of their investing and academic peers.

Thus, students are both entrepreneurs and investors. As entrepreneurs, they develop the business idea, prepare a video showing their products, and present the market strategy through a high user-friendly mode in line with "Kickstarter" standards. When students act as investors, they are asked to evaluate the projects proposed in the platform, providing feedback in the guise of investment choices. Besides the students, we asked 15 external experts (managers, directors of incubators, start-up operators, and funding providers) to act as investors.

B. Data Collection Procedure

Students were asked to fill a questionnaire (presurvey) at the beginning of the course. Details about the questions included in this questionnaire are analyzed in the next section. Subsequently, all the students were involved in the course which lasted 16 weeks (4 months) for a total of 72 h. This course aimed to disseminate the tools and basic knowledge useful for starting a new business, using the didactic support described above. Finally, at the end of the course (after 16 weeks), the same questionnaire (postsurvey) was readministrated (once the students had submitted their final projects of EE). Both pre- and postsurvey were distributed in an electronic way.

Fig. 2 reports all the steps of the study protocol as previously described.

Following Cohen et al. [95] and using the serial number of each student, the scores collected during the pre- and postsurvey were matched to capture the possible shift of investigated constructs. Thus, a Wilcoxon signed-rank test was performed to analyze whether the null hypotheses could be rejected (no difference between pre- and postsurvey scores).

C. Measurement

Sections of both questionnaire and their rationales are reported in Table II. The pre- and postsurvey differ only in the final section. While the personal information section (INFO) is reported both in the pre- and postsurvey questionnaire, the section related to the general satisfaction with the course and the platform PEAQS is reported only in the postsurvey questionnaire (STRI and PEAQS, respectively). For those items, we evaluate the course's satisfaction based on a Likert scale (1 to 5 for the modules evaluation, and 1 to 7 for the overall evaluation of the course and of PEAQS).

The sections related to Entrepreneurial Intention (EI), Attitude (ATT), SNs, and PBC were constructed following the guidelines provided by Ajzen [75] and Francis et al. [96] for the measurements of TPB constructs. To assess entrepreneurial self-efficacy, we used items proposed by McGee et al. [97], who developed and tested a multidimensional ESE instrument on a diverse sample that includes nascent entrepreneurs. Finally, we dedicate a section related to the University context and its capability to inspire, drive, and support new business (UA). For

TABLE II
SECTIONS OF THE QUESTIONNAIRE-DRIVEN ANALYSIS

Section label	Section description	ID Section
1.Entrepreneurial Self-Efficacy	Construct for measuring a person's belief in his/her ability to successfully launch a venture [97]	ESE
2.Entrepreneurial Intention	Construct for measuring a person's belief in his/her intention to start a new business [75]	EI
3.Attitude	Key precursor of entrepreneurial intention [75]	ATT
4.Subjective Norms	Key precursor of entrepreneurial intention [75]	SN
5.Perceived Behavioral Control	Key precursor of entrepreneurial intention [75]	PBC
6.University Atmosphere	Mechanisms influencing students' inclination toward entrepreneurship [98], [99]	UA
7.Entrepreneurship among parents	We ask if one or both parents are entrepreneurs and/or self-employed	EAP
8.Sociodemographic info	Questionnaire final section about Age, Gender, and Education level	INFO
9.Course satisfaction (only post survey)	Questionnaire final section about the course satisfaction	STRI
10.PEAQS satisfaction (only post survey)	Questionnaire final section about the use of the platform PEAQS	PEAQS

this section, the survey questions were based on North [98] and Scott [99].

The components of the constructs and related questions can be found in Table VII of Appendix. Some additional questions were also included in the study but omitted in this particular analysis. In most questions, participants were asked to express their degree of agreement with a statement on a 7-point Likert scale (from "Strongly disagree" to "Strongly agree."). The only exceptions concern Entrepreneurial self-efficacy, were we asked to indicate on a 5-point Likert scale (1 = very little, 5 = very much) how much confidence they had in their ability to engage in each of the different entrepreneurial selected tasks, and the two items related to Entrepreneurship among parents that we measured using a binary/dichotomous scale (EAP).

TABLE III
DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

Characteristic	Category	Percentage
Gender	Female	39.81%
	Male	60.19%
Nationality	Italy	99.07%
	Other	0.93%
Age	21	11%
	22	31%
	23	29%
	24	14%
	25	7%
	26	6%
	27	2%
	28	1%
At least one of my parents is an entrepreneur	Yes	48%
	No	52%
At least one of my parents is an organization majority shareholder	Yes	15%
	No	85%

D. Sample

The study draws on a sample of 210 students who attended a learning experience in a master class of management engineering degree of 72 h duration in 16 weeks. The participation in the study was part of optional and noncredit-bearing activities. For the presurvey, we received 205 complete survey responses. Instead, for the postsurvey questionnaire, we collected 141 responses. After that, respondents from the pre and postsurveys were matched based on a self-generated ID that only the respondents knew. This process resulted in 123 matched surveys. Among these 123 responses, 15 belong to students who followed the online course but did not participate in the group activity through the use of the PEAQS on line platform. This group of students has been removed from the analysis. The sample characteristics made of 108 final respondents are presented in Table III.

IV. FINDINGS

Data were analyzed using IBM SPSS Statistics Version 26.0 (IBM SPSS Inc. Chicago, USA). First, items used to measure constructs included in the questionnaires were assessed in terms of reliability. Acceptable Cronbach's alpha values (see Table IV) were obtained for each construct, both pre- and postsurvey. Then, a Kolmogorov–Smirnov test was conducted to check the normality of the data. The Kolmogorov–Smirnov test's null hypothesis is that the tested data were normally distributed. If the p-value obtained from the test is less than the selected alpha value (e.g., 0.05), then the null hypothesis is rejected. The results

TABLE IV
ANALYSIS OF RELIABILITY

Construct	Cronbach's Alpha presurvey	Cronbach's Alpha postsurvey	Items
Entrepreneurial Self-Efficacy (ESE)	.942	.901	6
Entrepreneurial Intention (EI)	.899	.898	5
Attitude (ATT)	.765	.723	4
Social Norms (SN)	.774	.714	4
Perc. Behavioral Control (PBC)	.773	.738	5
University Atmosphere (UA)	.921	.884	8
Course Evaluation (STRI)	–	.826	15
Group Activities on PEAQS (PEAQS)	–	.789	4

Note: Results based on valid cases (108 responses).

TABLE V
RESULTS OF WILCOXON SIGNED-RANK TEST

Null Hypothesis	Mean	Std. Deviation	Std. Error Mean	Sign.
The median of differences between ESE_{post} and ESE_{pre} is equal to 0	0.943	0.999	0.096	0.000*
The median of differences between EI_{post} and EI_{pre} is equal to 0	0.320	1.038	0.100	0.002*
The median of differences between ATT_{post} and ATT_{pre} is equal to 0	0.109	0.769	0.074	0.157
The median of differences between SN_{post} and SN_{pre} is equal to 0	0.053	0.681	0.066	0.480
The median of differences between PBC_{post} and PBC_{pre} is equal to 0	0.078	0.806	0.078	0.328

Note: *significant for $p = 0.05$.

of Kolmogorov–Smirnov showed that all items in the scale were significant at the significance level of 0.05, indicating that data were not normally distributed (results of the normality test are reported in Table VI of the Appendix).

Based on the normality test, the mean scale scores for the pre- and postsurvey items were evaluated for the significance of difference using the nonparametric Wilcoxon signed-rank test. This nonparametric data analysis is recommended as the better choice in non-normal distributions compared to Student's *t*-test, the power advantages of which are small even under normal theory [100].

Table V shows the statistical results of the pre- and post-survey constructs along with the related research hypotheses. It is important to note that for each construct, the Wilcoxon signed-rank test was performed to analyze statistical significance to determine whether the null hypotheses (no difference between pre- and postsurvey scores) can be rejected. Therefore, in the following, constructs that are statistically significant ($p < 0.05$) and with a mean score in the postsurvey higher than the presurvey will be discussed, indicating that these have improved participation in the course.

V. DISCUSSION

The debate about curricula design and teaching methods is intense [101], and the COVID-19 poses a significant challenge to education, especially for experiential courses as EE [5], [8], [35], [36], [101].

This article aimed to investigate how EE can be taught online to engineering students and if digital technologies can support experiential learning in an online environment. Moving from the research gap highlighted by Fayolle et al. [11] and Ratten and Jones [5] we focused our analysis on students in engineering school. Few studies consider the role of digital technologies in pursuing benefits for students involved in entrepreneurial education programs and especially for students in science and engineering disciplines, who are encouraged to explore marketing their research, promoting universities' role in innovation and job creation [102]. Our empirical research investigates specific aspects of EE devoted to this specific target of students that may offer a promising path toward a more experiential education fostered by a didactical method, including digital technologies.

Our research covered the redesign of an online EE course targeted to engineering students supported by the adoption of digital tools and organized around the key priorities of providing knowledge and competencies for the following: concept invention; business case implementation; product description, and get to market. This is coherent with the recommendations provided by Duval-Couetil et al. [102] to design a course enabling engineering students to play a more active and informed role in marketing their idea.

Based on our results, students reported an extremely high course evaluation. An average of 6.35 on a 1–7 point Likert scale was registered. For each module proposed in the course, on a 1–5 point Likert scale, we registered an overall appreciation (see section "Course Evaluation" in Table VII of the Appendix).

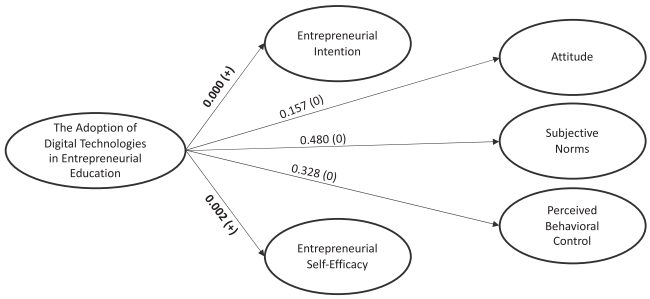

Fig. 3. Results of tested hypotheses. Note: The numerical values on the arrows indicate the level of significance of the tested hypothesis. In bold are highlighted the significant relationships (+), while those not in bold show nonsignificant relationships (0).

Moving to the "Group Activities on PEAQS" (relative section in Appendix Table VII), we revealed the platform's great influence in supporting group work among students (with 5.42 of average on a 1–7 Likert point scale). We registered the digital platform's elevated impact on students' awareness of the development stages of a new business (5.35 on average). We also report an upbeat assessment of the digital platform to improve students' capabilities in building new relational networks (4.27). Those results support the role of PEAQS in an online course and the capability of a digital platform to create a collaborative atmosphere for students involved in an entrepreneurship program.

Results, then, provide evidence that exposure to an online entrepreneurial education program with the adoption of specific digital technologies such as PEAQS positively impacts students' intentions to become entrepreneurs. We tested five hypotheses related to the most common factors that literature investigates when dealing with entrepreneurial education efficacy (see Fig. 3).

Regarding hypothesis 1 related to entrepreneurial self-efficacy in online courses, the Wilcoxon signed-rank test result is statistically different. The adoption of a digital tools created the beliefs of students to be able to manage innovation, risk, and leadership. Whether digital technology can be an opportunity to quickly develop such capability, even if online, is positively confirmed by the analysis.

Regarding hypotheses 2.1–2.4, the TBP [75] verified the existence of a relationship between EE, rethought in an online environment, and entrepreneurial intention [78]. Effects of digital technologies adopted in EE are still in their infancy, with few studies demonstrating the benefits. Entrepreneurial education has the typical features of experiential learning that requires interactions, socialization, and knowledge sharing in a community of students. The investigation explored four components of the relationship between digital technologies adoption for entrepreneurial learning and entrepreneurial intention.

Hypothesis 2.1 is supported by the statistical significance obtained through the Wilcoxon signed-rank test. We can affirm that several benefits can be obtained using digital tools in supporting specific aspects of entrepreneurship courses. This evidence is also supported by the concrete intention of students to start a business, with few projects that moved in into a real market experience. This is in line with recent research according to which novel digital technologies can be adopted by entrepreneurship courses to face the pandemic situation and to propose a novel way to organize the learning process within the classroom aiming to develop entrepreneurial capacity [8], [51].

We then tested the role played by attitude, SNs, and PBC. Those three factors are considered to be precursors of behavior to start a business. A project-based learning experience supported by a digital tool is supposed to be supportive of students' behavior even if they are participating in an online course.

Although the Wilcoxon signed-rank test does not support hypothesis 2.2, 2.3, and 2.4, regarding hypothesis 2.2 about the attitude, digital technologies may not support teamwork to be creative, and collaboration could have been reduced by the online conditions of all groups' members. Distance may have influenced the exchange of opinions and exchange of views. Interaction among students that could positively affect their attitude toward behavior both at instrumental and affective level [66] had been probably a weakness of an online course.

The rejection of hypothesis 2.3 is close to what happens for attitude. Individuals conform to other group members' opinions, thus converging to social norms because of their need to feel accepted. The online condition partially generated this perception, influencing a low level of collaboration, openness, and interaction among group members.

Finally, hypothesis 2.4 is partially rejected, and this is probably explained by the fact that the online condition did not provide a full environment in which students can become more confident in their means and less concerned about the difficulties and resources needed to take action.

VI. Conclusion

Our research starts from the TBP [75] and offer novel insights on how experiential entrepreneurial education course may enhance entrepreneurial intention and orientation in STEM students. Results obtained in our analysis provide evidence that exposure entrepreneurial education program supported by digital technology offered online have a positive impact on students' intentions to become entrepreneurs. Prior studies of entrepreneurial education in STEM programs [25], [103], [104] hinted at the fact that technology education influenced entrepreneurial attitudes and behaviors, but this is the first study on STEM students exposed to an online program with the adoption of specific designed digital tools.

Digital technologies' massive adoption for designing and delivering EE courses can provide significant opportunities for university students to enrich their learning experiences and virtual classroom interaction by designing more engaging, interactive, student-centered practices that boost students' motivation and learning outcomes [105], [106]. The COVID-19 emergency has forced universities worldwide to reorganize their teaching and research activities using virtual and online learning [8].

This challenging situation represented an important occasion to reflect on how to redesign experiential learning courses such as entrepreneurship courses for engineering students by leveraging

digital technologies' potential. Universities show an increasing commitment to stimulating entrepreneurship for STEM students with the aim of contributing to both societal and economic development [107]. Educating the next generation of engineers could be a suitable way to achieve this result. We agree with Turner and Gianiodis [106] according to which the diffusion of entrepreneurship pedagogy across university campuses has created opportunities, and challenges for entrepreneurship scholars, as well as university administrators. Findings from this research showed how EE delivered online can have a positive impact on university students' self-efficacy and intention.

We must understand how to propose a new educational model to be adopted even after the pandemic emergency is resolved. Specifically, analyzing as well as examining how entrepreneurial education delivered through the adoption of digital tools for STEM disciplines and especially engineering students has important implications for theory and practice.

A. Implications for Theory

The article contributes to the EE debate for STEM Students in times of COVID-19. Previous work on EE for engineering curriculum [53], [103] hinted at the fact that digital technology education influenced entrepreneurial attitudes and behaviors. We confirmed how the adoption of digital tools in online system programs on entrepreneurship might help in increasing entrepreneurial attitude, but we also revealed that behavior is strongly related to the social component of human interaction that suffers from on line learning.

The technical, contextual, interaction, and emotional limits encountered during the delivery of EE courses can be partially mitigated by adopting digital tools and systems that would aspire to create a more inclusive and collaborative atmosphere. A digital challenge-based solution is required in EE, especially if it is a mandatory course, where the stimulus to achieve the results and create an entrepreneurial intention must be higher than the obligation to take part in the program. The general limits of the EE delivered online can also be mitigated through the involvement of mentors, start-up operators, and managers coming from the entrepreneurial ecosystem that is not locally constrained for so long [5]. Testimonials coming from all over the industrial and academic world can quickly reach the classroom of engineers, thanks to digital technologies, and they can represent a stimulus for students to learn from best practices. The adoption of digital technologies to deliver entrepreneurship contents could also be a suitable strategy when the COVID-19 pandemic ends, to allow diversified modalities of community creation and engagement. Despite this positive aspect, face-to-face interaction is highly recommended to build the sense of community among students within the learning process, especially in the starting phase of an EE course to allow people to know each other and create a team composed of students with complementary backgrounds for developing their ideas [8]. Overall, a deep reflection on the opportunity to reconfigure EE through digital technologies needs is required for policy and practical implication.

B. Implications for Policies and Practices

This study provides useful details of pedagogical design and methods on how to design specific digital technologies features of education programs to impact student intentions toward entrepreneurial activities.

The adoption of digital tools for delivering an entrepreneurship course may have mitigated the distance among participants, but important considerations can be made from a practical perspective. On the side of universities, the most interesting implication regards the EE activities conducted with methodological aspects such as support for the development of the business idea or implementation of the business plan supported by digital tools. University administrators and faculty can learn from our results in terms of implementation and adoption of digital tools supporting online students and implementing such solutions, especially when COVID-19 ends. An online learning experience must be completed, in an entrepreneurial education program, with a face-to-face activity to support the socialization aspects of project and business plan development. The online learning modalities in this specific type of education allowed students to develop the critical skills of entrepreneurship, e.g., motivation, goal attainment, determination, and management of risks, although a balanced approach between face-to-face and online is strongly recommended. The design of a mixed approach (blended learning) seems to be the most suitable one to be adopted by University governance and policy maker that should sustain the personalization of an entrepreneurship course according to the digital skills of attending students allowing them the exposure to entrepreneurs as mentors who can inspire their entrepreneurial intention. Therefore, an important practical implication for implementing distance learning in EE is to consider all factors and conditions, enabling and inhibiting ones, to design a successful learning process. And, university administrators need an evidence base to guide their resource allocation to improve the ability of instructors and support staff in managing digital tools and guiding students toward the adoption of digital technologies. Students need to strengthen confidence in their technological abilities when improving their entrepreneurial abilities.

C. Limitations of the Study and Future Research

It is difficult for either engineers and scientists who lack managerial skills or management students who lack engineer or science-oriented knowledge to be successful [51]. Moving from this consideration, we can affirm that developing and creating EE for STEM students through digital technologies require additional effort to develop an effective education. Study limitations require the need to experiment and compare the same EE course with other students to prove the study's validity again.

APPENDIX

See Tables VI and VII.

TABLE VI
DESCRIPTIVE STATISTICS AND TESTING FOR NORMALITY OF THE STUDY VARIABLES

		Normal Parameters [a,b]		Most Extreme Differences				Asymp.
Items	N	Mean	Std. Deviation	Absolute	Positive	Negative	Test Statistic	Sig. (2-tailed)
ESEpre_1	108	3,97	1,307	0,151	0,151	–0,136	0,151	,000[c]
ESEpre_2	108	3,73	1,358	0,177	0,177	–0,121	0,177	,000[c]
ESEpre_3	108	3,68	1,465	0,178	0,178	–0,113	0,178	,000[c]
ESEpre_4	108	3,85	1,433	0,178	0,178	–0,109	0,178	,000[c]
ESEpre_5	108	3,64	1,475	0,149	0,149	–0,115	0,149	,000[c]
ESEpre_6	108	4,79	1,485	0,131	0,128	–0,131	0,131	,000[c]
ESEpost_1	108	4,87	0,948	0,212	0,186	–0,212	0,212	,000[c]
ESEpost_2	108	4,65	1,146	0,176	0,159	–0,176	0,176	,000[c]
ESEpost_3	108	4,75	1,201	0,175	0,168	–0,175	0,175	,000[c]
ESEpost_4	108	4,92	1,078	0,197	0,182	–0,197	0,197	,000[c]
ESEpost_5	108	4,71	1,160	0,175	0,175	–0,153	0,175	,000[c]
ESEpost_6	108	5,42	1,033	0,186	0,184	–0,186	0,186	,000[c]
EIpre_1	108	3,16	1,536	0,182	0,182	–0,105	0,182	,000[c]
EIpre_2	108	5,02	1,522	0,166	0,128	–0,166	0,166	,000[c]
EIpre_3	108	4,19	1,688	0,156	0,112	–0,156	0,156	,000[c]
EIpre_4	108	4,82	1,662	0,163	0,097	–0,163	0,163	,000[c]
EIpre_5	108	5,25	1,408	0,161	0,117	–0,161	0,161	,000[c]
EIpost_1	108	4,27	1,132	0,193	0,159	–0,193	0,193	,000[c]
EIpost_2	108	5,16	1,448	0,177	0,177	–0,173	0,177	,000[c]
EIpost_3	108	4,63	1,678	0,145	0,118	–0,145	0,145	,000[c]
EIpost_4	108	4,89	1,524	0,165	0,137	–0,165	0,165	,000[c]
EIpost_5	108	5,10	1,360	0,171	0,104	–0,171	0,171	,000[c]
ATTpre_1	108	4,15	1,126	0,244	0,219	–0,244	0,244	,000[c]
ATTpre_2	108	5,67	1,184	0,203	0,130	–0,203	0,203	,000[c]
ATTpre_3	108	6,26	0,890	0,288	0,203	–0,288	0,288	,000[c]
ATTpre_4	108	4,77	1,592	0,169	0,089	–0,169	0,169	,000[c]
ATTpost_1	108	4,28	1,049	0,271	0,271	–0,229	0,271	,000[c]
ATTpost_2	108	5,92	1,060	0,217	0,153	–0,217	0,217	,000[c]
ATTpost_3	108	6,28	0,874	0,314	0,204	–0,314	0,314	,000[c]
ATTpost_4	108	4,81	1,377	0,147	0,147	–0,131	0,147	,000[c]
SNpre_1	108	5,76	1,183	0,220	0,147	–0,220	0,220	,000[c]
SNpre_2	108	6,06	1,012	0,260	0,175	–0,260	0,260	,000[c]
SNpre_3	108	5,75	1,103	0,229	0,129	–0,229	0,229	,000[c]
SNpre_4	108	0,48	0,502	0,350	0,350	–0,331	0,350	,000[c]
SNpre_5	108	0,15	0,357	0,513	0,513	–0,339	0,513	,000[c]
SNpost_1	108	5,73	1,258	0,223	0,157	–0,223	0,223	,000[c]
SNpost_2	108	6,14	1,000	0,259	0,194	–0,259	0,259	,000[c]
SNpost_3	108	5,97	1,098	0,242	0,175	–0,242	0,242	,000[c]
SNpost_4	108	0,41	0,494	0,388	0,388	–0,292	0,388	,000[c]
SNpost_5	108	0,15	0,357	0,513	0,513	–0,339	0,513	,000[c]
PBCpre_1	108	4,99	1,643	0,175	0,111	–0,175	0,175	,000[c]
PBCpre_2	108	5,02	1,318	0,161	0,141	–0,161	0,161	,000[c]
PBCpre_3	108	5,71	1,268	0,256	0,155	–0,256	0,256	,000[c]
PBCpre_4	108	4,23	1,392	0,175	0,124	–0,175	0,175	,000[c]
PBCpre_5	108	3,69	1,603	0,140	0,140	–0,135	0,140	,000[c]
PBCpost_1	108	4,83	1,525	0,171	0,171	–0,126	0,171	,000[c]
PBCpost_2	108	5,41	1,128	0,182	0,160	–0,182	0,182	,000[c]
PBCpost_3	108	5,74	1,271	0,201	0,161	–0,201	0,201	,000[c]
PBCpost_4	108	4,38	1,266	0,216	0,145	–0,216	0,216	,000[c]
PBCpost_5	108	3,68	1,426	0,164	0,160	–0,164	0,164	,000[c]
UApre_1	108	4,16	1,375	0,147	0,147	–0,130	0,147	,000[c]
UApre_2	108	4,27	1,425	0,167	0,167	–0,147	0,167	,000[c]
UApre_3	108	4,19	1,511	0,160	0,160	–0,127	0,160	,000[c]
UApre_4	108	4,06	1,503	0,144	0,144	–0,115	0,144	,000[c]
UApre_5	108	3,97	1,531	0,135	0,135	–0,110	0,135	,000[c]
UApre_6	108	3,12	1,575	0,216	0,216	–0,100	0,216	,000[c]
UApre_7	108	3,87	1,479	0,139	0,139	–0,129	0,139	,000[c]
UApre_8	108	4,01	1,417	0,173	0,126	–0,173	0,173	,000[c]
UApost_1	108	5,09	1,219	0,198	0,127	–0,198	0,198	,000[c]
UApost_2	108	5,17	1,315	0,228	0,143	–0,228	0,228	,000[c]
UApost_3	108	4,94	1,327	0,195	0,119	–0,195	0,195	,000[c]
UApost_4	108	5,90	1,004	0,281	0,173	–0,281	0,281	,000[c]
UApost_5	108	6,03	0,952	0,257	0,160	–0,257	0,257	,000[c]
UApost_6	108	5,52	0,942	0,205	0,200	–0,205	0,205	,000[c]
UApost_7	108	5,63	0,991	0,210	0,210	–0,173	0,210	,000[c]
UApost_8	108	5,51	1,018	0,204	0,173	–0,204	0,204	,000[c]

Note: [a]Test distribution is Normal.
[b]Calculated from data.
[c]Lilliefors Significance Correction.

TABLE VII
QUESTIONNAIRE ITEMS' ASSESSMENT AND STATISTICAL RESULTS

Section	Question	Question ID	Mean Pre	Mean Post	Mean diff. (a)	Sig. (2-tailed)
Entrepreneurial self-efficacy	To grasp market demand for a new product or service	ESE_1	3.98	4.83	0.898	0.000
	Developing a new product or service for meeting customers' needs	ESE_2	3.74	4.58	0.917	0.000
	Managing the innovation process	ESE_3	3.72	4.71	1.074	0.000
	Commercialize a new business idea	ESE_4	3.88	4.88	1.065	0.000
	Setting up new relations and sharing information	ESE_5	3.64	4.67	1.074	0.000
	Developing an effective communication strategy for promoting new products or services	ESE_6	4.74	5.43	0.630	0.000
Entrepreneurial Intention	I am ready to become an entrepreneur	EI_1	3.09	4.17	1.111	0.000
	I would like to undertake a new business in future	EI_2	4.95	5.05	0.139	0.248
	I am next to undertaking a new business	EI_3	4.14	4.54	0.435	0.011
	I am strongly oriented to undertake new business in future	EI_4	4.77	4.79	0.065	0.588
	Despite conflicting opinions, I would still like to become an entrepreneur	EI_5	5.28	5.03	-0.148	0.213
Attitude	Being an entrepreneur implies more advantages than disadvantages	ATT_1	4.18	4.24	0.130	0.195
	An entrepreneurial career is attractive	ATT_2	5.66	5.85	0.250	0.024
	Being an entrepreneur could imply a successful life	ATT_3	6.29	6.24	0.019	0.826
	My professional goal is business-based	ATT_4	4.76	4.74	0.037	0.782
Subjective Norms	Family's perception about my entrepreneurial career	SN_1	5.81	5.74	−0.028	0.773
	Friends' perception about my entrepreneurial career	SN_2	6.07	6.16	0.083	0.348
	University colleagues' perception about my entrepreneurial career	SN_3	5.78	5.99	0.222	0.039
	Being innovative is positively considered in the society I live in	SN_4	0.48	0.41	−0.074	0.011
Perc. Behavioral Control	I will do everything to create and manage my business	PCB_1	4.93	4.70	−0.157	0.246
	I am able to defend my personal interests	PCB_2	5.09	5.40	0.389	0.003
	If I had the right resources, I would like to become an entrepreneur	PCB_3	5.73	5.69	0.028	0.803
	Based in my planning, I am pretty sure that everything is going to work accordingly	PCB_4	4.27	4.34	0.148	0.229
	I am capable at figuring out what will happen in my future life	PCB_5	3.70	3.71	−0.019	0.885
University Atmosphere	My university context inspires the emergence of new business ideas	UA_1	4.17	5.09	0.935	0.000
	In my university, a positive climate boosts entrepreneurship	UA_2	4.30	5.16	0.898	0.000
	In my university, students are encouraged to become entrepreneurs	UA_3	4.21	4.95	0.750	0.000
	Courses and formative activities improved my awareness, values and entrepreneurial intention	UA_4	4.07	5.82	1.843	0.000
	Courses and formative activities increased my organizational attitude	UA_5	4.02	5.96	2.056	0.000
	Courses and formative activities improved my managerial competencies in business venturing	UA_6	3.16	5.49	2.398	0.000
	Courses and formative activities increased my capabilities to build new relational networks	UA_7	3.88	5.60	1.759	0.000
	Courses and formative activities supported me in seeking new opportunities	UA_8	4.02	5.55	1.500	0.000
Entrepreneurship among Parents	At least one of my parents is an entrepreneur	EAP_1	.50	.42	−0.08	0.011
	At least one of my parents is an organization majority shareholder	EAP_2	.16	.16	0.00	1.000
Course Evaluation	Evaluate "The Problem Solving" module	STRI_1	–	3.72		
	Evaluate "The New Venture" module	STRI_2	–	4.05		
	Evaluate "The Crowdfunding" module	STRI_3	–	3.55		
	Evaluate "The Gamification" module	STRI_4	–	4.26		
	Evaluate "The Startup" module	STRI_5	–	3.56		
	Evaluate "The Intellectual property" module	STRI_6	–	3.17		
	Evaluate "The Spin-off" module	STRI_7	–	3.94		
	Evaluate "The Online Brand Identity" module	STRI_8	–	4.04		
	Evaluate "The Incubation process" module	STRI_9	–	3.60		
	Evaluate "The Design Thinking" module	STRI_10	–	4.39		
	Evaluate "The Cyber Security" module	STRI_11	–	3.45		
	Evaluate "Channels and Logistics" module	STRI_12	–	4.17		
	Evaluate "The Funding" module	STRI_13	–	3.79		
	Evaluate "The Elevator Pitch" module	STRI_14	–	4.18		
	Evaluate the overall course of "Strategy and Entrepreneur 2020-21"	STRI_15	–	6.35		
Group Activities on PEAQS	How do you think digital technologies like PEAQS increase your capabilities to build new relational networks	PEAQS_1	–	4.27		
	How do you think digital technologies like PEAQS improve your awareness of the development stages of a new business	PEAQS_2	–	5.35		
	How do you think digital technologies like PEAQS increase your propensity for entrepreneurship	PEAQS_3	–	4.66		
	How do you think digital technologies like PEAQS increase your ability to work in a team	PEAQS_4	–	5.42		

Note: [a] (+) items that positively improved; (-) items that are negatively, and (0.00) items that did not change

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