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Digital Entrepreneurship:
From Entrepreneurial Intentions to Entrepreneurial Activity
The role of IT knowledge

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The role of IT knowledge

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Dedications

To my father Konstantinos

To Martha, Elena, Konstantina and Marios

To Fotis and Maria

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Abbreviations

AI	Artificial Intelligence
CSE	Computer Self-Efficacy
DE	Digital Entrepreneurship
DEA	Digital Entrepreneurial Activity
DEI	Digital Entrepreneurial Intention
EI	Entrepreneurial Intention
EPL	Entrepreneurial Program Learning
GEM	Global Entrepreneurship Monitor
GUESSS	Global University Entrepreneurial Spirit Students' Survey
ICT	Information Communication Technology
IT	Information Technology
LR	Literature Review
OPC	Opportunity Competence
PSED	Panel Study of Entrepreneurial Dynamics
SEM	Structural Equations Model
TPB	Theory of Planned Behavior
MBA	Master in Business Administration

Abstract

Purpose: In the recent years it has become evident that Digital entrepreneurship (DE) gains momentum and tends to become the norm of contemporary entrepreneurial activity. Information Technology (IT) education provides students with valuable knowledge and skills on emerging digital technologies, theoretically offering them an advantage in comparison to students from other scientific backgrounds. Proficiency in IT, combined with an entrepreneurial mindset cultivates students' creativity and confidence to cope with uncertainty, as well as their opportunity identification ability regarding digital business. Therefore, future entrepreneurial activity in the digital context depends on students' digital entrepreneurial mindset, which is frequently expressed in the literature through digital entrepreneurial intentions. Entrepreneurship courses traditionally nurture the development of intentions, through the cultivation of entrepreneurial competencies. As a result, an increasing number of entrepreneurship courses are offered in engineering disciplines, aiming to supplement technical knowledge with entrepreneurial knowledge and skills, and entrepreneurship course designers strive to follow the evolution of emerging digital technologies. However, although DE research attracts a lot of scholarly interest, the educational perspective of DE still remains an understudied research niche.

The purpose of this study is twofold.

Firstly, to shed light in a neglected niche in the intersection between digital entrepreneurship (DE) and entrepreneurship education and circumscribe DE education as field of research. It is important to document how entrepreneurship education responds to the ongoing integration of emerging digital technologies with the entrepreneurial process, and introduce a DE education conceptual framework in order to facilitate theoretical and practical development in the field, promote new conceptualizations and aid new educational approaches and new curriculum designs.

Secondly, to examine the role of IT-knowledge on the development of opportunity recognition, digital entrepreneurial intentions and digital entrepreneurial activity, following the calls from scholars in the field. The role of IT-Knowledge as a predictor of students' digital entrepreneurial intentions and subsequent digital startup activity is examined and a theoretical model is proposed. The combination of IT-Knowledge and Entrepreneurial Program Learning in the formation of digital entrepreneurial intentions is explained, as well as their impact on opportunity identification for further engagement with nascent entrepreneurial activity in the digital context.

Methodology: In order to serve the first purpose of the study, a literature review was conducted, using a concept driven, semi-structured developmental methodology, based on grounded theory and reinforced with increased systemization, for the identification and analysis of peer reviewed articles. Previous literature reviews were taken as a basis in order to define the search keywords. The main search retrieved articles from three databases, based on a predefined research protocol and strict eligibility criteria. The final set of articles was classified in four primary dimensions, synthesized from several sub-streams of research. Each sub-stream capturing a different view of DE education emerged through open, axial and selective coding of concepts. The combined perspectives of these dimensions resulted in a new DE conceptual framework.

In order to serve the second purpose of the study, a cross-sectional survey administered to university students is used for data acquisition. The sample consists of university students in IT related majors. The research methodology and hypotheses testing is based on descriptive statistics, and structural equation models.

Findings: The conceptual interrelation between the studies examined in the literature review, revealed an ample view of the various schools of thought in the research field, offering also a better understanding on how entrepreneurial education addresses the practical requirements of digital entrepreneurship. A four dimensional conceptual framework produced highlights pedagogy and learning, success factors and barriers, behavioral approach and DE ecosystems as the current trends of research. Between the proposed directions for future research the need to examine the role of IT-knowledge on opportunity identification competence and subsequently on digital entrepreneurial intentions and digital entrepreneurial activity is emerging. The results indicate significant positive impact of IT-Knowledge on opportunity recognition, on digital entrepreneurial intentions and on digital entrepreneurial activity.

Originality: Although digital entrepreneurship research has gained significant momentum in recent years, little attention is paid to its educational dimension. The body of knowledge on DE develops in a rather uncontrolled and fragmented manner, and the systematic study of the field from an educational perspective was missing. This study offers a representative picture of the topic, highlights current trends of research, synthesizes literature from different disciplinary origins, and provides linkages between unconnected streams of research and points out various research gaps. Finally it proposes a conceptual framework

to circumscribe DE education as a field of study and serve as a basis to help future research move forward.

The results of the methodological part of the study, explain the role of IT-Knowledge on the development of opportunity identification competence, and provide a link between intentions and digital entrepreneurial activity. The important role of specific IT-knowledge on students' opportunity identification competency is also highlighted in contrast to general ability to use computer software. The findings increase our theoretical understanding of the mechanism IT-Knowledge acts on digital entrepreneurial intentions and digital entrepreneurial activity either directly or through opportunity competency. Significant practical implications are offered for entrepreneurship education and policy.

1. Introduction

1.1. Problem definition and research objectives

Digital entrepreneurship gains momentum and tends to become the norm of modern entrepreneurial activity. Information Technology (IT) education offers valuable digital technology knowledge and skills to students, who theoretically share a competitive advantage compared to students from other scientific backgrounds. Future entrepreneurial activity in the digital domain is depending on students' entrepreneurial attitude, which represents the way of facing or seeking opportunities, based on one's accumulated knowledge and experience (Souitaris et al., 2007). The entrepreneurial attitude is frequently examined through digital entrepreneurial intention (DEI). The entrepreneurial attitude involves personal traits, such as creativity and confidence to cope with digital business uncertainty. Students, especially those from IT related fields consider the lack of entrepreneurial knowledge and skills a serious barrier to entrepreneurship (Sitaridis and Kitsios, 2019a). Entrepreneurship courses traditionally aim to develop these intentions, through the cultivation of related competencies. Nowadays, courses continuously adapt to the requirements of emerging digital technologies, and as a result, an increasing number of entrepreneurship courses are offered in engineering and IT disciplines. The attendees of these courses usually hold a strong technical background, which is supplemented by entrepreneurial knowledge and skills. The purpose of this paper is to propose and test a theoretical model for the examination of specific IT knowledge as a predictor of digital entrepreneurial intentions and subsequent startup activity of students in the digital space.

However, although DE research attracts a lot of scholarly interest, the educational perspective of DE still remains an understudied research niche. As a result the existing literature largely consists of empirical studies, conceptual papers are generally missing, and qualitative studies are scarce. The literature develops in an unorganized manner and authors tend to be overoptimistic regarding the effects of entrepreneurial courses. On the other hand the interdisciplinary nature of DE results in a variety of perspectives and approaches to the subject, which is depicted by the multiplicity of terms used in the literature. Additionally, few articles study DE from an educational point of view and it can be ascertained that literature reviews addressing the issue of DE Education are missing (Sitaridis and Kitsios, 2023a). The lack of theoretical frameworks embracing all these view points and

circumscribing DE Education as distinct field of research in the intersection of DE and Entrepreneurship Education is evident.

The following questions seek for answers in the theoretical part of the thesis:

- What are the current trends in digital entrepreneurship education research?
- Which are the most prolific journals?
- Which are the most prolific authors?
- How has the number of publications evolved over time?
- What are promising avenues for future research?

Following the reasoning expressed previously and in order to provide answers to the questions and shed light in the field of DE Education research, a literature review is the most suitable tool. The resulting DE Education conceptual framework would facilitate theoretical and practical developments in the field and highlight research gaps for prominent future studies.

On the other hand, it is common sense that emerging digital technologies play a key role in the development of digital entrepreneurial activity. As more complex digital technologies enter the entrepreneurial arena, new combinations of skills are needed (Sousa and Rocha, 2019). Those familiar with the technologies, potentially possessing the required knowledge and skills are in vantage point and may become aware of venture opportunities, earlier than others (Del Giudice and Straub, 2011; Steininger, 2019). However, the exact mechanism which turns digital knowledge, among other factors such as entrepreneurial program learning, into a driver for opportunity identification and creates the conditions for actual steps in nascent entrepreneurial activity in the digital context remains unknown. Until now, most studies using student samples operationalized prospective entrepreneurial behavior in terms of intentions to start a business. This approach, mainly based on the Theory of Planned Behavior (Ajzen et al., 2009; Krueger and Carsrud, 1993), received a lot of criticism, since the linkage between intentions and actions was considered pretty weak, mainly due to the time lapse between the two (Meoli et al., 2020). The study of intentions and actions from a Human Capital perspective would be a more promising approach, as human capital is positively related to entrepreneurial outcomes (Martin et al., 2013), and opportunity identification (Kakouris and Liargovas, 2020; Karimi et al., 2014; Shane and Venkataraman, 2000). Moreover, a shift of research interest from intentions to actions would be very

important element of future studies because it would add robustness to the results. Finally, the examination of these interrelations between construct has not been examined in the context of DE, to the best of our knowledge.

Some of the questions seeking for answers in this part of the thesis are the following:

- How is digital (IT) knowledge related to students' digital entrepreneurial intention?
- Is there a predictive link between intentions and nascent entrepreneurial activity in DE?
- Is digital (IT) knowledge a good predictor of nascent DE activity?
- Does Entrepreneurial Program Learning (Knowledge) predict nascent DE activity?
- What is the role of digital (IT) knowledge on opportunity identification ability?

In order to examine the role of IT-knowledge on the development of opportunity recognition, digital entrepreneurial intentions and digital entrepreneurial activity, following the calls from scholars in the field (Carpenter and Wilson, 2022; Costa et al., 2018; Cui et al., 2021; Kreuzer et al., 2022; Steininger et al., 2022; von Briel et al., 2021), and examine whether entrepreneurial knowledge or combined with IT knowledge can predict nascent digital entrepreneurial activity and opportunity recognition ability of students, a number of theoretical models are examined, including the constructs of interest. The models are tested using a student sample. Finally, beyond other interrelations between constructs, the link between intentions and actions is also examined.

1.2. Thesis contribution

This work explores and defines DE education as field of research, identifies the required adaptation in entrepreneurship education due to the rapid adoption of emerging new digital technologies, such as AI and immersive technologies in business. The analysis and classification of the reviewed articles allows for a conceptual framework to be introduced, offering future researchers with valuable assistance. Additionally, combining different theoretical perspectives, that of human capital theory in an 'informed' EI theoretical model (Hindle et al., 2009), the research offers explanation on the impact of Digital Technology both on intentions and actions towards entrepreneurship development in the digital domain answering the call of scholars for more research on the role of digital technology on individual's opportunity identification (Nambisan, 2017; Steininger, 2019; von Briel et al.,

2021). Finally the link between entrepreneurial intentions and actions is examined (Meoli et al., 2020; Mir et al., 2022), improving our theoretical understanding of the important role of IT-Knowledge in opportunity identification ability. Regarding practice, current entrepreneurship pedagogies in academia are reported and the proposed framework can serve as a roadmap on how should entrepreneurship education adapt and diversify following the rapid technological disruption, and what pedagogical settings should be suitable for the effective transfer of appropriate knowledge and experience to learners (Tarabasz *et al.*, 2018).

1.3. Thesis Structure

The thesis is structured as follows:

The first chapter is an introduction to the problem and the scope and the contributions of the current research.

Chapter two provides background information on related work. The research carried out is presented, starting with previous literature reviews and definitions of the related terms. Search keywords and databases are defined and the adopted search protocol based on contemporary literature review literature is described, along with the eligibility criteria used for the identification and screening of articles. The articles in the sample are analyzed and relevant excerpts are extracted, a conceptual synthesis of which allows the important concepts to surface. These concepts and their sub-dimensions are to be used for the development of a theoretical framework of DE Education, in order to discover the suitable research gap for this piece of research and proposals for future research directions.

Chapter three presents the proposed theoretical model and elaborates each component and builds hypotheses based on relevant literature. The instrument for data collection is described, as well as the population under study. The research methodology is further analyzed and justified.

Chapter four presents the application of the theoretical model and discusses the results and hypotheses, making comparisons to previous research.

Chapter five presents the conclusions drawn from the results, and discusses the theoretical and practical implications, as well as the limitations of the present work. Finally, directions for future research are offered.

2. Theoretical Background

(based on Sitaridis and Kitsios, (2023) LRv6.57 – LRv6.75)

2.1. Introduction

In the previous chapter we made a brief introduction to the aim of the research along with some insights on the research methodology. In this chapter the state of the art regarding digital entrepreneurship and entrepreneurship education is presented through an intensive literature review (LR). The LR documents and presents existing definitions of terms and illustrates research models used by prior research in the field, in order to identify central concepts that should be employed in the adopted research model.

The LR is organized as follows:

Section 2 discusses the theoretical background, the research questions, definitions of terms and the research background through the presentation of previous literature reviews. Section 3 presents the methodology of the literature review. Section 4 focuses on the analysis of concepts generated. Section 5 draws conclusions and defines the research gap addressed further on.

Entrepreneurship is the driver for personal prosperity, financial and social development, as well as productivity (Gorgievski and Stephan, 2016; Kuratko, 2005; Nabi et al., 2017). Universities adopt an entrepreneurial culture and combine entrepreneurship courses in the curriculum in order to inspire their students (Fernández-Pérez et al., 2019; Hahn et al., 2020), and provide them with creativity skills and entrepreneurial attitudes such as entrepreneurial alertness, facilitating opportunity exploitation and value creation (Gundry et al., 2014; Obschonka et al., 2017). Entrepreneurial initiatives occur mainly in the form of new business ventures launched either by individual entrepreneurs, or by entrepreneurial teams identifying and pursuing business opportunities, In many cases these entrepreneurial endeavors take place in the corporate environment and are organized by innovative employees who share the same entrepreneurial spirit with entrepreneurs, also known as intrapreneurs (Antoncic and Hisrich, 2001; Rae and Woodier-Harris, 2013). Both entrepreneurship and intrapreneurship are critical for economic and social development and heavily rely on human capital developed through formal education and training (Antoncic and Hisrich, 2001; Parker, 2011). The entrepreneurs' experience and education is closely related to the success of digital startup (Zaheer et al., 2019a), and a strong educational

background increases probabilities of reaching entrepreneurial milestones (Ratzinger et al., 2018). Additionally, there are positive insights linking education with human capital and entrepreneurial outcomes confirmed by meta analytic research, justifying the heavy investments on entrepreneurship education from governments, universities and private organizations (Martin et al., 2013).

Entrepreneurship education also plays a significant role in providing the required knowledge to enable opportunity identification (Kakouris and Liargovas, 2020; Karimi et al., 2014; Shane and Venkataraman, 2000) and exercises the cognitive mechanisms for opportunity evaluation through the available information (Gielnik et al., 2012; Marvel et al., 2016). The transformation of entrepreneurial processes through the utilization of emerging digital technologies, not only offered competitive advantages to those investing in IT capabilities but also created new opportunities to entrepreneurs through easy access to the global markets (Del Giudice and Straub, 2011; Steininger, 2019). Although, information has become more accessible to larger numbers of stakeholders through digital communication technology utilization (Yeganegi et al., 2021), the scene of possible competitors has also widened compared to brick and mortar entrepreneurship. The increased competition, intensified the demand for human capital, in terms of capabilities, and made it a significant driver for digital innovation (Suseno and Abbott, 2021) and entry into digital entrepreneurship (Mir et al., 2022).

Digital Entrepreneurship (DE) conceptually emanates from the use of digital technology as a facilitator, as a mediator, as the product itself and finally as the ubiquitous component of every entrepreneurial attempt (Steininger, 2019). Traditional business models have been transformed by digital technology in a considerable manner and other totally new digital ones have been created (von Briel et al., 2018a). This relatively new phenomenon has shown accelerated dynamics of evolution in the recent years, showing progress both from theoretical and technological point of view (Elia et al., 2020). DE dominated the entrepreneurial landscape, especially during the restrictions and social distancing of the recent pandemic, due to the acceleration in digital technology adoption, which entrained rapid and groundbreaking changes in the entrepreneurial scheme. As more disruptive digital technologies intrude in business models, a complex combination of innovation, leadership and management skills is required (Sousa and Rocha, 2019), which has serious implications for DE teaching and learning (Ratten and Jones, 2021). Scholars who have closely studied the various facets of DE, realize that the body of knowledge develops rapidly, in a rather

uncontrolled and fragmented fashion, and few papers cope with DE educational perspective (Kraus et al., 2019; Zaheer et al., 2019a), leaving a considerable void in the literature regarding the consecutive adoption of disruptive new digital technologies in business and how it should be addressed from an educational viewpoint. Despite the rapid developments in entrepreneurship education, the interdisciplinary growth of DE as a field of research, often outpaces instructional designs regarding required knowledge and skills (Birch et al., 2017; Kakouris and Liargovas, 2020; Ratten and Jones, 2021). Additionally, the effect of entrepreneurship education and training tends to be overestimated by mainstream studies, gasping to catch up with the latest developments. An opportunistic rivalry of studies presenting a plethora of success stories in traditional entrepreneurship, frequently overestimates the impact of entrepreneurship education without sound empirical evidence (Martin et al., 2013; Matlay, 2004). The lack of theoretical frameworks analyzing DE education conceptual dimensions, hinders the evolution of original research pertained to the theoretical and practical implications of the new emerging technologies engaged in DE. Finally, empirical results are not organized in a productive way, raising difficulties in the evaluation, and subsequent dissemination of the results in policy and practice. Inability of assessment of the empirical results of educational interventions based on the new emerging technologies would create a non-factual image of the research field, with diverse consequences for practice.

In a recent literature review Sitaridis and Kitsios, (2023) tried to capture the literature landscape in the intersection between digital entrepreneurship and entrepreneurship education, and circumscribe DE education as field of research. The study used an interdisciplinary focus, in order to document current research trends dealing with the practical and theoretical implications of disruptive new digital technologies incorporated in entrepreneurship, and point out challenges and future research directions, in regard to DE education and training. The most critical results provided in this study are:

1. The identification of the current trends in digital entrepreneurship education research and
2. The presentation of promising avenues for future research.

The semi-structured literature review methodology chosen as the most suitable tool for the research, aimed to:

- (a) Present the state of the art in entrepreneurship education research regarding DE education,

- (b) Identify trending research directions through conceptual classification of articles,
- (c) Bridge fragmented areas of research,
- (d) Highlight research gaps and
- (e) create a research agenda (Snyder, 2019).

The study sought both for conceptual and empirical papers, using different approaches to the subject of DE education. These approaches are: a) education on DE, examining the development of DE opportunity awareness, b) education for DE examining ways of implementing business ideas into a digital business ventures, and finally, c) education through DE, concerning the experiential acquisition of DE knowledge and skills (Secundo et al., 2021).

2.2. Definitions

Digital Technology

Emerging digital technologies, such as artificial intelligence (AI), immersive technologies, mobile and cloud computing, social media, internet of things and data analytics, intertwined into digital platforms, offer ubiquitous access to infrastructures and services, creating opportunities for entrepreneurship and disruptive innovation (Nambisan, 2017; Sousa and Rocha, 2019). Different actors have the possibility to constantly interact with and through digital platforms, overcoming physical barriers, and gain instant access to enormous amounts of information. Sophisticated ways to combine information from multiple sources in an ubiquitous manner are developed, offering to actors increased opportunity awareness, facilitated decision making and reduced risk (Giuggioli and Pellegrini, 2023; Obschonka and Audretsch, 2020; Ratten, 2013). The aforementioned benefits increase the potential for value creation for entrepreneurs (Zott and Amit, 2007).

Digitalization

Digitalization is 'the integration of multiple technologies into aspects of daily social life' (Caputo et al., 2021). Business models innovation through the use of digital technologies creates new opportunities for revenue and value creation (Kraus et al., 2019). Advances in cloud computing, AI, immersive technologies and the Internet of Things involves fundamental changes in the socio-cultural context, since it influences various aspects of human interaction with digital business, either as a customer, as an employee or as a

business manager (Stolterman and Fors, 2004). Broader research perspectives on the implications of digital technologies on entrepreneurship from cognitive, social and institutional perspectives are needed (Nambisan, 2017), as well as new explanatory theories examining DE from a digitalization perspective (Ratten and Usmanij, 2021). Additionally, digitalization enables the transfer of knowledge from the individual to the university and DE ecosystem and back (Toniolo et al., 2020). The role of educators becomes more complex, entrepreneurship courses need to be adapted to new digital competencies required, in order to offer coaching to students and entrepreneurs on the utilization of emerging digital technologies (Lamine et al., 2021).

Digital Entrepreneurship

Digital Entrepreneurship refers to the human orchestrated efforts to transfer assets, services or parts of the business in the digital domain (Kraus et al., 2019), shifting the traditional way of exploiting of business opportunities through leveraging digital technologies (Rippa and Secundo, 2019; Younis et al., 2020).

2.3. Previous Literature Reviews

Next, in order to briefly present fundamental background information on contemporary DE research, and highlight research streams and gaps, the findings of a number of significant literature reviews on DE shown in Table 1, are discussed.

The substitution of the traditionally fixed relations between business actors, processes and outcomes, with flexible ones urged by digitalization and emerging digital technologies, creates new opportunities for entrepreneurs and offers the modern tools to help them cope with uncertainty and risk. The impact of digital technology on classic theoretical entrepreneurship concepts, needs to be examined, since the implications for practice and the urgency for new well matched methodologies for studying these phenomena is recognized by scholars (Nambisan, 2017). Opportunities, challenges and success factors regarding digital business models become the centre of research interest. The stages of the digital entrepreneurship process, from idea conception to the actual digital enterprise startup; digital platform strategies, for networking and growth; digital ecosystems, information sharing and collaboration; and social digital entrepreneurship challenge DE education, given that new skills are required, to tackle with the constant introduction of cutting-edge technologies in DE (Kraus et al., 2019). Information technology (IT) and information systems become central to the development of DE business models. Four roles

for IT are highlighted; IT as an infrastructure based facilitator used for business processes support, IT as a mediator offering the IT-based network customer relation support, IT as an outcome/product of the business model, and IT as ubiquity as a combination of all the previous (Steininger, 2019). A research agenda for academic entrepreneurship proposes democratization and inclusiveness in DE (Rippa and Secundo, 2019). However, there is a 'dearth' of literature examining entrepreneurship education in the context of digital technology and dynamic frameworks which would improve our understanding of the DE phenomenon are missing (Zaheer et al., 2019b). The crucial role for entrepreneurship education is highlighted by the required knowledge and skills, as well as the ability of the individual digital entrepreneur to acquire new knowledge (Satalkina and Steiner, 2020a). The impact of digital technology on academic entrepreneurship is important and especially on experiential learning, on the "maker space movement" and on entrepreneurial opportunity discovery and innovation (Secundo et al., 2020a). The university offers the required entrepreneurial knowledge and skills and it also creates DE ecosystems through knowledge spillovers.

From the previous literature reviews it becomes evident that the educational dimension of DE is generally neglected and it is only partially addressed from the viewpoint of academic DE. Although typical entrepreneurship education strives to follow the evolution of the field this is done in a fragmented manner. The increased momentum of DE development requires the timely examination of DE education state in order to address its future needs.

Table 1. Previous Literature Reviews

<i>Author(s)</i>	<i>Title</i>	<i>Period</i>	<i>Journal</i>
<i>Year</i>	<i>Methodology/Period/Number of papers</i>	<i>No. Papers</i>	
Nambisan, S. (2017)	"Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship." n.a	n.a. n.a.	Entrepreneurship Theory and Practice
Kraus, S; Palmer, C; Kailer, N; Kallinger, FL; Spitzer, J (2019)	"Digital entrepreneurship A research agenda on new business models for the twenty-first century" Evidence-informed literature review (Tranfield et al., 2003), Quality control (Bouncken et al. 2015)	2007-2018 35	International Journal of Entrepreneurial Behavior & Research

Steininger, D.M. (2019)	“Linking information systems and entrepreneurship: A review and agenda for IT-associated and digital entrepreneurship research.” Systematic Literature Review, Webster and Watson (2002), Xiao, Califf, Sarker, and Sarker (2013).	1990-2017	Information Systems Journal
Rippa P., Secundo G. (2019)	“Digital academic entrepreneurship: The potential of digital technologies on academic entrepreneurship”	n.a. n.a.	Technological Forecasting and Social Change
Zaheer H., Breyer Y., Dumay J. (2019)	“Digital entrepreneurship: An interdisciplinary structured literature review and research agenda” Evidence-informed literature review, (Tranfield et al., 2003)	2000-2019	Technological Forecasting and Social Change
Satalkina, L. and Steiner, G. (2020)	“Digital entrepreneurship and its role in innovation systems: a systematic literature review as a basis for future research avenues for sustainable transitions” PRISMA Method, (Kleijnen, J.; Moher, D 2009)	2014 – 2018	Sustainability (Switzerland)
Secundo G., Rippa P., Cerchione R. (2020)	“Digital Academic Entrepreneurship: A structured literature review and avenue for a research agenda” Structured literature review, (Massaro et al., 2016; Petticrew & Roberts, 2006; Tranfield et al., 2003).	2005 - 2018	Technological Forecasting and Social Change
Kollmann T. (2022)	“Eras of Digital Entrepreneurship” Scoping literature review, Templier and Pare´ (2015)	1990-2020	Business & Information Systems Engineering

Sitaridis and Kitsios, (2023) having examined the latest research in DE education, conclude that all recent studies avoided to discuss the educational consequences of DE development, with an exception to the work of Secundo *et al.*, (2020), who mentioned the anticipated educational requirements for DE. As a result, theoretical frameworks embracing the different conceptual dimensions of DE education research are missing, hindering scholarly research on the subject and creation of novelty. Moreover, the discussion of the theoretical

and practical implications of the empirical results is not organized in a productive way, raising difficulties in the evaluation of their effectiveness in practice.

The authors propose a conceptual framework which would aid future research and would deepen our understanding in specific research areas. Moreover the conceptual framework would allow the prolific combination of research sub-streams in an interdisciplinary manner, opening new research avenues.

2.4. Methodology

A concept-driven literature review methodology used for this study, has been used in previous Information Systems and Management research (Kunz and Sonnenholzner, 2023; Steininger, 2019). The original methodology initially proposed by Webster and Watson, (2002) was further reinforced with elements of Grounded Theory (Wolfswinkel et al., 2013) and review systemization (Kraus et al., 2020). The aim of the authors was to provide trustworthy results, rather than eliminating biases at all costs (Kunisch et al., 2023)

This type of literature review is appropriate for emerging topics, such as DE Education, in order to produce new conceptual frameworks (Snyder, 2019; Templier and Paré, 2015). Contrary to methodologies derived from life sciences, the research design is not tightly planned, and offers researchers the freedom to make conceptual explorations (Snyder, 2019; Tranfield et al., 2003).

A search for existing literature reviews was conducted, to serve as a basis for the selection of appropriate databases and keywords for the identification of articles during the main search, followed by backward and forward searches, employed in a recursive manner until no new concepts result from the analysis. The backward search scans through the references of the selected papers for missing papers, whereas, the forward search identifies the most recent articles citing key papers found in previous steps. A screening for duplicates of the papers gathered during the identification follows. Lastly, a set of predefined eligibility criteria are used to eliminate irrelevant articles. Scanning the titles, keywords and abstracts of remaining papers results in a pool of papers relevant to the scope and aims of the study, for full text processing. Eligible papers were classified according to their content, using a concept centric approach.

The identification procedure of articles is briefly shown in Figure 1. This process is described in full detail regarding the databases, the keywords and the eligibility criteria used in Sitaridis and Kitsios, (2023).

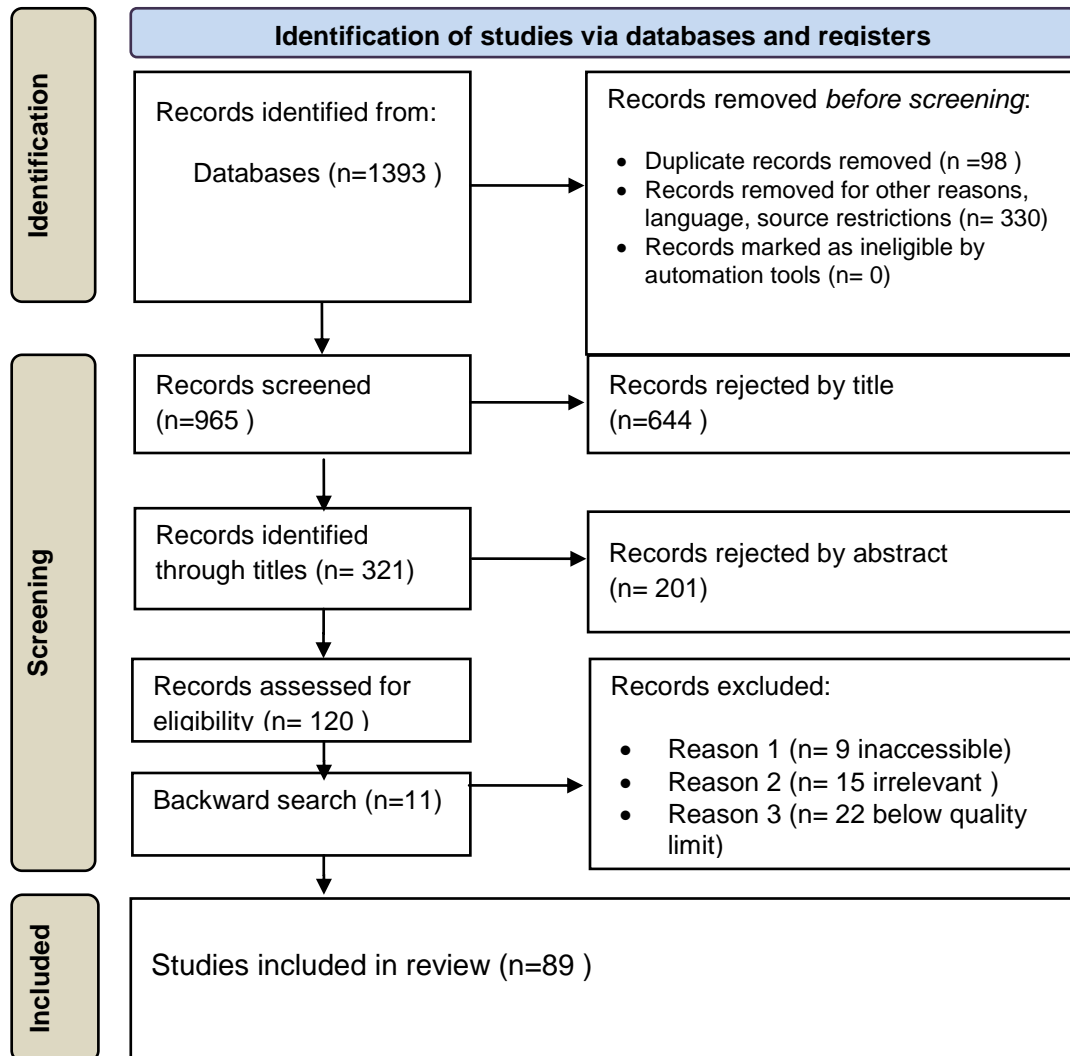


Figure 1. Identification of Articles

2.5. Results

Number of papers per year

The number of articles published each year is shown in Figure 2, demonstrates how the research field has evolved over the years. From 2001 to 2017, the research interest in DE education is in its 'infancy' (Kraus et al., 2019), with few articles per year, most of them published in journals in the fields of Information Systems and Education sciences. Research production increases from 2017 when the first literature reviews on DE are published. This shows an increased research interest in DE education, as the field's important role in the

development of DE research and practice is recognized. Many relevant articles have been published thereafter, in high quality journals from the fields of Entrepreneurship, Management and Psychology.

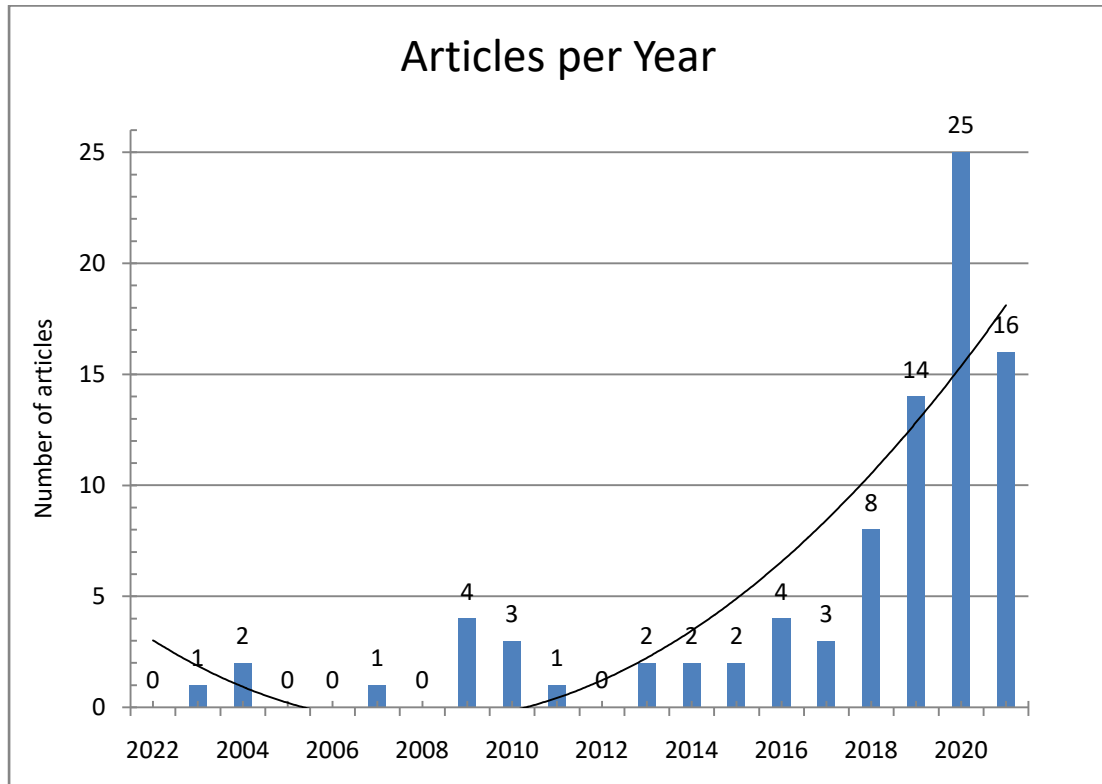


Figure 2. Number of papers per year

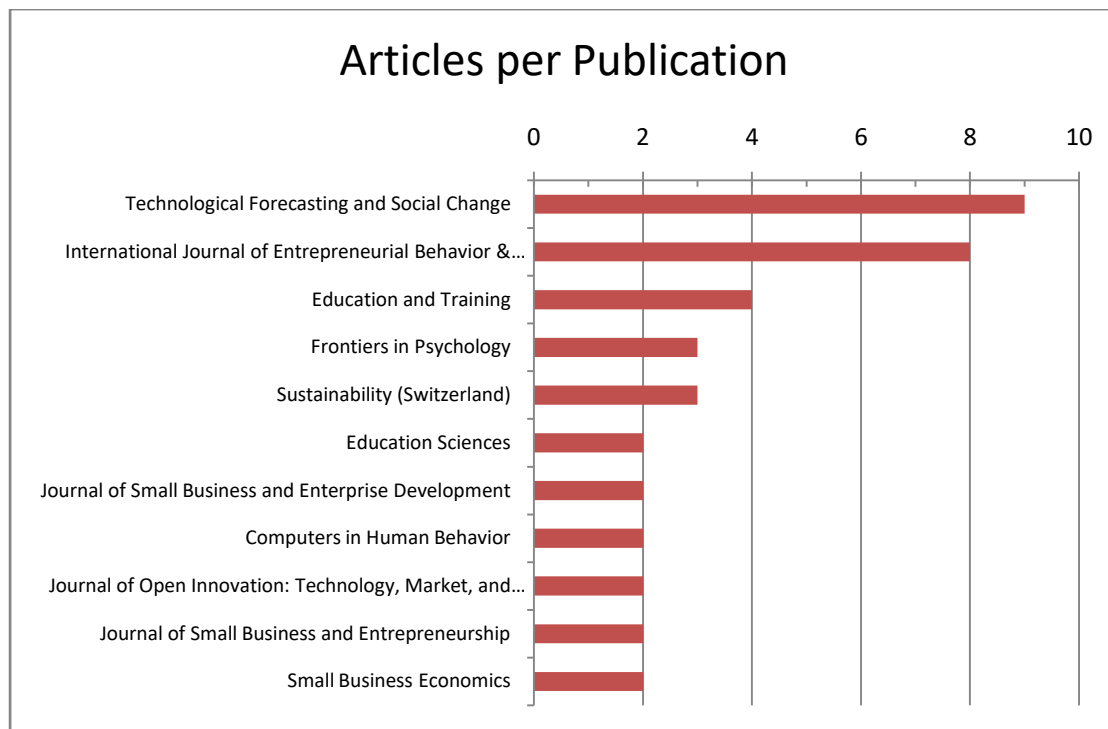


Figure 3. Distribution of articles per journal

Prolific Journals

The number of papers per journal is shown in Figure 3. *Technological Forecasting and Social Change* is the most prolific journal, with 9 articles published between 2019 and 2021. *International Journal of Entrepreneurial Behavior & Research* follows with 7 of the 8 articles published between 2018 and 2022 and one of the earliest articles published in 2004. In the third place comes *Education and Training*, with 4 of the 5 articles published from 2018 to 2021 and one article published in 2009. *Frontiers in Psychology* and *Sustainability* have published from 3 articles each in 2020.

Prolific Authors

The most productive authors based on article publication, are presented in Figure 4. *Secundo G, Elia G. Margherita A. and Matlay H.* appear to be more prolific authors in the field, by the time this study was conducted, who have published at least 3 papers each. They are followed by many authors with 2 papers each. *Secundo G. and Rippa P., Elia G. and Margherita A., Zaheer H., Breyer Y. and Dumay J., Chang S.H and Wang C.L* are the most frequently collaborating co-authors. Co-authorships and collaborations offer insights on the spreading of research in different disciplines.

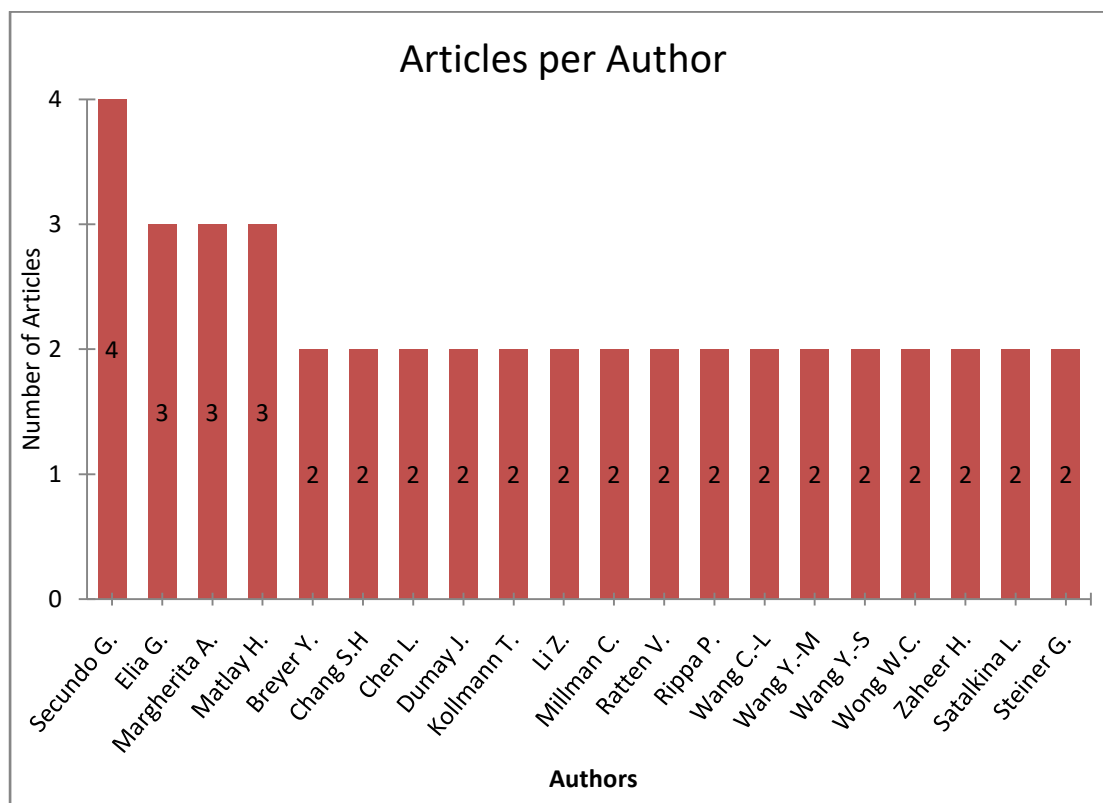


Figure 4. Prolific authors

Research methods

Thirty nine papers (43.8%) in the sample have used quantitative approaches, in the form of questionnaires. Twelve papers (13.5%) have used qualitative methods such as interviews or open ended questions, whereas only seven papers (7.8%) used mixed approaches (questionnaires and interviews). Researchers have mainly focused on students in order to collect data, since students are considered an eligible data collection source for entrepreneurial research. The case studies refer to innovative educational interventions, use of digital learning platforms and educational offerings for experiential learning. Figure 5 presents the number of papers per methodology.

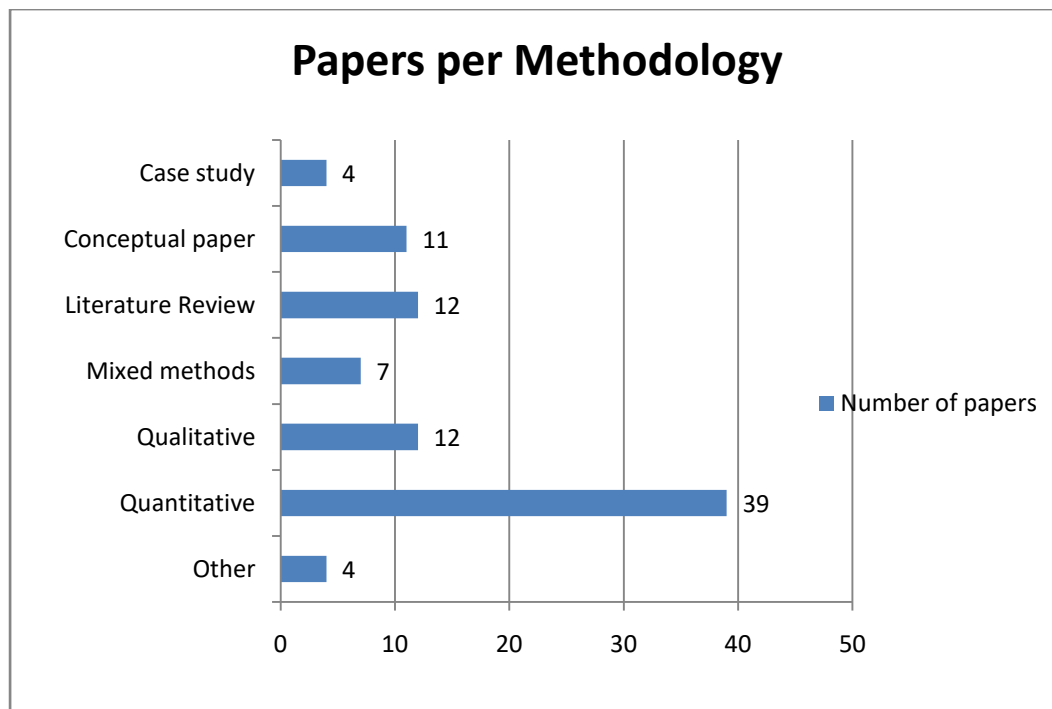


Figure 5. Papers per methodology

2.6. Analysis of concepts

The analysis and classification of papers was based conceptual analysis, before synthesis and integration of concepts was employed, so as to find useful links between previously disconnected studies (Kraus et al., 2020), and improve our understanding of the DE phenomenon (Kunisch et al., 2023).

Paper Analysis and Classification

Eighty nine (89) papers were analyzed based on the different patterns of terms and methodologies used in the examined papers, resulting in several sub-streams of research, which were then categorized into four main conceptual dimensions. The analysis phase of the papers followed the recommendations of Wolfswinkel et al., (2013), sought for patterns of findings, in order to identify sub-streams of research. Finally, the interrelations between sub-streams of research resulted in the main conceptual dimensions. The main dimensions identified are presented in the DE education conceptual framework, integrating the key topics associated to each sub-stream. The conceptual framework represents current trends in digital entrepreneurship education and highlights under-studied areas (Kunisch et al., 2023; Snyder, 2019).

Table 2. Main conceptual dimensions and sub-streams of research

<i>Main conceptual dimensions</i>	<i>Sub-streams</i>	<i>Topics</i>	
Pedagogy and learning	ICT dominance in business	<ul style="list-style-type: none"> • Business idea exploration with IT • New knowledge economy • Digital mindset/computational thinking • Disruptive technology change • Adaptation of entrepreneurship courses 	
	Learning approaches	<ul style="list-style-type: none"> • Experiential learning • Project based learning • University incubators • Internships • Maker spaces 	
	Digital Learning Environments	<ul style="list-style-type: none"> • MOOCs • Game simulations 	
Success factors and barriers	Enabling factors	<ul style="list-style-type: none"> • Resources • Strategy • Business model 	
	Constrains	<ul style="list-style-type: none"> • Required action • Administrative constrains 	
	Personality	<ul style="list-style-type: none"> • Self esteem • Self-efficacy • Positive thinking 	
Behavioral approach	Motivational factors	<ul style="list-style-type: none"> • Bounded rationality • Innovativeness • Social support/Gender • Leadership • Entrepreneurial knowledge/skills • Competency 	
		Ecosystems	<ul style="list-style-type: none"> • Entrepreneurial pipeline • Collective intelligence entities • Information networks
		Teams and networking	<ul style="list-style-type: none"> • Informal collaboration networks • E-business teams • Social networks
Ecosystems dimension	Human Capital	<ul style="list-style-type: none"> • Education • Entrepreneurial Knowledge/skills • Competency frameworks 	

Next, the main conceptual dimensions and their corresponding substreams of research are briefly presented.

Pedagogy and Learning

The oldest and overabundant stream of research is that of pedagogy and learning, showing that the academic community early recognized the need for addressing DE educational requirements.

ICT dominance in business

The impact of the new knowledge economy and prevailing of groundbreaking technological change alters the physiology of business. The need for students and faculty members to embrace a digital mindset becomes more eminent. Higher order thinking skills and computational thinking are required (Kang and Lee, 2020; Tarabasz et al., 2018). However, due to disruptive nature of technological change, academic research on entrepreneurship education is not on the edge of the evolutions. Experience from MBA courses offering special topics on disruptive technology, suggests that entrepreneurship education should focus on the intersection of emerging new technologies with management education (Allen, 2020), in order to address the challenges of incorporating the new technologies in educational settings (Ratten and Usmanij, 2021). The financial and economic benefits from AI usage in entrepreneurship for example, demand novel approaches in entrepreneurship education in order to explore and teach the new possibilities arising for opportunity recognition and decision making (Giuggioli and Pellegrini, 2023).

Learning Approaches

Project based learning (Pereira et al., 2020), blended self-managed action learning (Shurville and Rospigliosi, 2009), design thinking (Androutsos and Brinia, 2019), self-directed learning (Morris and König, 2021), offer student entrepreneurs flexibility, engagement and independence.

Digital based learning (Rohm et al., 2021), Co-design based learning workshops, prototyping, online assistance offered by mentors combined with typical entrepreneurial education practices, such as pitching and business planning redesigned for DE (Laptev and Shaytan, 2022; Secundo et al., 2021), foster the sense of community, improve networking and accelerate team formation.

Experience obtained through authentic situations, such as student clubs, workshops, incubators, internships and maker spaces increases students' entrepreneurial self-efficacy (Monllor and Soto-Simeone, 2020) and supplies them with valuable skills and competencies,

especially useful for technology students (J. C. Chang et al., 2018; Le Dinh et al., 2018; Secundo et al., 2020b).

Digital Learning Environments

Cultivating new skills charted on the 21st century skills framework, are required for the successful digital ventures (Rayna and Striukova, 2021). However, skills related to newer technologies, such as AI and augmented reality technologies, which were only recently used to improve digital interaction in universities' simulated business environments, have been decisively introduced in entrepreneurial practice only after the social distancing restrictions during the COVID pandemic (Ratten, 2020).

The use of MOOCs in technology entrepreneurship courses create business opportunities through knowledge spillovers through common experiences and expectations shared among participating students (Žur, 2020). Digital collaboration, digital workplace and digital awareness become the key DE competencies developed through MOOCs (Thanachawengsakul and Wannapiroon, 2021). However, the functions of digital learning platforms, that support academic entrepreneurship through knowledge exchange between university and business need to be defined (Linzalone et al., 2020). Innovative ways to transfer hands on experience online are needed (Vorbach et al., 2019), considering implementation effectiveness (Carenys and Moya, 2016; Wang and Chiou, 2020).

Success factors and barriers

Although Entrepreneurship Education can improve key success factors such as experience, knowledge and social capital (Zaheer et al., 2019b), administrative constraints frequently hinder the development of sustainable student startups, especially during their early stages (Muafi et al., 2021). Entrepreneurship education however, focuses on individual human capital, rather than on the formation of entrepreneurial teams (Ladeira et al., 2019). A significant success factor for team formation and social capital development is the entrepreneur's personality. A decisive personality, open to experience and striving for achievement, provides the required intrinsic and extrinsic motivation (Yeh et al., 2020), which can be improved through a solid background of entrepreneurship education and training (Chae and Goh, 2020; Shimoli et al., 2020).

Behavioral approach

A behavioral approach aims to highlight motivational factors supporting the development of students' intentions towards DE.

Personality and Motivation

Cyber-entrepreneurial self-efficacy (Chang et al., 2020), extrinsic and intrinsic motivation, extroverted personality and openness to experience (Yeh et al., 2020), act as drivers for business students DE intentions (Wang et al., 2016). These personality traits can be cultivated by entrepreneurship education (Chae and Goh, 2020).

Social support and Gender

Gender has been positively associated with male IT students' intention to start internet businesses (Millman et al., 2010). However, social support offers extrinsic motivation for female students (Alzamel et al., 2020), and unemployed women (Mand et al., 2018), to create digital ventures.

Self-Efficacy

IT knowledge, IT adoption and entrepreneurial tendency (Zenebe et al., 2018), computer self-efficacy and personal innovativeness in IT (Chen, 2014, 2013; Wang et al., 2020) and cyber-entrepreneurial self-efficacy are significant predictors of DE intentions (S. H. Chang et al., 2018; Youssef et al., 2021).

Entrepreneurial knowledge and skills

Entrepreneurial skills in terms of technical knowledge, opportunity identification and managerial skill, were positively related to DE intention (Siriattakul and Jermsittiparsert, 2019). DE education need to focus on entrepreneurial competency specific to digital business (Farani et al., 2017), while performance on specific entrepreneurial skills and competencies, could substitute students' self-reported measures (Ferrerias-Garcia et al., 2019).

Ecosystem approach

This stream of research examines the different sets of actors involved in DE, e.g. individuals, teams as the determinants of the entrepreneurial ecosystem (Satalkina and Steiner, 2020b).

DE Ecosystems

The theories of entrepreneurial pipeline and entrepreneurial ecosystems could provide the theoretical underpinnings for the transition to DE (Birch et al., 2017). Intellectual property rights regulations should ensure adequate information availability for research purposes in an ecosystem (Yeganegi et al., 2021). Interdependencies between who, why, how and what interconnect the actors of the entrepreneurial ecosystem into a collective intelligence entity (Elia et al., 2020).

Teams and networking

Teams and social networking, and even informal collaboration networks become more important for DE than entrepreneurial knowledge and previous IT knowledge (Scuotto and Morellato, 2013). IT competencies required in e-business, are valuable for the formation of entrepreneurial teams (Kollmann et al., 2008). However, face-to-face contacts and positive dispositional affectivity are also required for effective social networking (Pérez-Fernández et al., 2020).

Human capital

Human capital refers to the individual's experience and skills described by one's education, training, intelligence, skills, health, and other things such as loyalty and punctuality valued by employers ("Human capital definition," 2022). Human capital is related to performance outcomes. This is confirmed by the positive relation of entrepreneurship education with entrepreneurial outcomes and performance (Martin et al., 2013). Human capital, including teamwork and skills of interpersonal relations is cultivated through entrepreneurship courses (Beránek, 2015). The level of education has also a significant impact on the ability to attract external funding (Ratzinger et al., 2018). However, Entrepreneurship Education needs to continuously adapt to the new entrepreneurial competencies, associated with leadership, management and innovation required, by the continuous integration of emerging digital technologies in digital platforms, (Sousa and Rocha, 2019; Tarabasz et al., 2018; Toniolo et al., 2020). The role of human capital, becomes critical, especially for ambitious DE ventures, since technological knowledge and resource investments required are escalated as the complexity of DE increases (Martinez Dy, 2022). For example, scholars already consider the

utilization of AI as an enabler technology in DE, in addition to the possibilities for innovative AI aided teaching and learning techniques, however studies do not delve into the consequences of generative AI and opportunities offered both for individual entrepreneurs and entrepreneurship education (Giuggioli and Pellegrini, 2023; Obschonka and Audretsch, 2020).

The list of articles allotted per conceptual dimension and sub stream is presented in Table 10, in the Appendix A.

2.7. Conclusions

Sitaridis & Kitsios, (2023a) conclude that there is a need for new theoretical frameworks development, embracing the different conceptual dimensions of DE education research, in order to sustain research novelty. The authors recognize a void in the literature, regarding the study of the adaptation required in entrepreneurship education due to the continual introduction of emerging new technologies in entrepreneurship scheme, and the lack of theoretical frameworks describing the various dimensions of DE education research. The conceptual framework proposed would offer future researchers valuable assistance and allow the combination of sub-streams of research in an interdisciplinary manner, producing new fertile conceptualizations. Moreover, the current attempts of entrepreneurship pedagogy have been charted and the proposed framework can offer guidance to entrepreneurship educators and course designers.

The great variety of terms in the literature, shows a fruitful diversity in DE Education research (Matlay, 2004). However, this might also signify latent conceptual debates, and absence of pedagogical focus, as a result of the aforementioned fragmentation of the literature in diverse streams of research. Consequently, it is urgent for scholars to provide deeper and broader theoretical foundations of DE pedagogy and training.

Regarding future research, Sitaridis & Kitsios, (2023a) underline the recent call of scholars (Cui et al., 2021; Kreuzer et al., 2022; Steininger et al., 2022) for further research on the role of IT competencies on entrepreneurial opportunity identification. More specifically, competency driven DE education frameworks using a human capital perspective, and the development of meta-competence frameworks, are prominent topics (Prendes-Espinosa et al., 2021), which would offer a better understanding on the role of digital technologies in opportunity identification competency (Steininger et al., 2022; von Briel et al., 2021). Moreover, they would provide a link between digital competencies delivered in

entrepreneurship courses and business performance on the firm level (Reis et al., 2021). In this regard, both traditional research methodologies, as well as new event-driven methodologies, e.g. the multi-method insider action research (Nzembayie et al., 2019), would shed more light on skills required for entrepreneurial practical design and implementation. An additional practical benefit from a competency driven DE education approach would be the increased robustness to the DE intentions research through the use of tangible competency measurement instruments instead of self-reported measures (Ferrerias-Garcia et al., 2019). Theoretically, the combination of human capital theory with the behavioral approach of DE intentions would extent theoretical frameworks and move the research field forward.

3. Methodology

In the previous chapter through an extensive review of the literature a research gap was identified regarding the need to improve our theoretical understanding on the role of digital technologies on opportunity identification ability, especially in the context of DE (Nambisan et al., 2019; Steininger et al., 2022; von Briel et al., 2021). Since opportunity alertness is considered an indispensable prerequisite for entrepreneurial activity (Cui et al., 2021), it is necessary for entrepreneurship education to pay attention to opportunity identification, by providing students with specialized training and the latest digital knowledge (Carpenter and Wilson, 2022; Costa et al., 2018). The application of existing knowledge drives innovation and increases the chances for the creation of new digital entrepreneurial ventures (Kreuzer et al., 2022). As a result, the demand for new digital knowledge and skills by digital entrepreneurs is ever growing (Sahut et al., 2021; Sousa and Rocha, 2019), however the exact role of digital knowledge on the development of students' DE intentions, opportunity identification and subsequent new venture creation has not been examined in the literature. In this section, the role of IT-Knowledge as a predictor of students' DE intentions and subsequent digital startup activity is examined and a theoretical model is proposed. The role of IT-Knowledge in the formation of digital entrepreneurial intentions is examined in combination to that of Entrepreneurial Program Learning, as well as their impact on opportunity identification and further engagement with entrepreneurial activity in the digital context. The research design is based in a cross-sectional survey administered to university students, used for data acquisition. The sample consisting of university students in IT related majors, allows hypotheses testing based on descriptive statistics, and structural equation models. The results indicate significant positive impact of IT-Knowledge on opportunity recognition, on digital entrepreneurial intentions and on digital entrepreneurial activity.

3.1. Constructs and hypotheses

Entrepreneurial Intention

Intentions largely determine whether or not someone will get involved with some specific behavior. Intentions are developed through mental processing and anticipation, prior to exercising the behavior (Wu and Wu, 2008). The link between intentions and actions is

explained by the Theory of Planned Behavior (TPB), which is widely accepted in intentional research (Ajzen, 1991). The TPB is frequently used in entrepreneurship research due to its increased predictability and it dominates entrepreneurial intention (EI) related literature (Martins et al., 2019). The TPB has been used for the prediction of the EIs on a sample IT students with good predicting results (Sitaridis and Kitsios, 2017). Several instruments have been developed for the measuring students' EI, based on the TPB due to its predictive effectiveness (Liñán and Chen, 2009). Entrepreneurial intention is a good predictor of actual involvement with entrepreneurship given the right business opportunity (Schar et al., 2014) and it has frequently been used as a proxy for actual behavior in the literature (Meoli et al., 2020). Although a positive relation between EI and actual entrepreneurial behavior in the form of a business startup has been reported by previous research (Joensuu-Salo et al., 2015; Kautonen et al., 2015), the TPB received also some criticism regarding the intention to action link which is frequently moderated by factors of the social environment (Meoli et al., 2020) such as education and training.

In this study a human capital approach is followed, since human capital embraces the domain specific knowledge required to start a venture, which is usually delivered through educational interventions (Dutta et al., 2015). The rationale behind this approach is an 'informed' EI conceptualization based on human and social capital, where intentions represent a proxy for ones entrepreneurial mindset shaped by their possession of knowledge, information availability and advice offered through social interaction (Hindle et al., 2009).

Opportunity competency

Entrepreneurship requires a diverse set of competencies. One essential competency for the entrepreneur is that of recognizing gaps in the market and assessing them as possible opportunities for value creation. Opportunity identification competency and alertness is essential part of the entrepreneurial mindset (Cui et al., 2021; Obschonka et al., 2017) and has a central role during the stage of nascent entrepreneurship development (Marvel et al., 2016), as it shows a positive relation to entrepreneurial goal intentions (Esfandiar et al., 2019). Opportunity identification is considered as one of the entrepreneurship related human capital qualifications of the prospective entrepreneur (Carpenter and Wilson, 2022; Costa et al., 2018; Cui et al., 2021; Kreuzer et al., 2022; Steininger et al., 2022), along with entrepreneurial attitude and entrepreneurial intention, since it heavily relies on knowledge and skills (Martin et al., 2013; Marvel et al., 2016). Opportunity identification is essential for

search based opportunity entrepreneurship and its relation to human capital has been studied in general entrepreneurship literature (Marvel, 2011). However, it has not been studied sufficiently in the context of Digital Entrepreneurship (Kreuzer et al., 2022; Sitaridis and Kitsios, 2023a; Steininger et al., 2022).

Hypothesis 1

H1a. Opportunity competence has a positive impact on digital entrepreneurial intention

H1b. Opportunity competence has a positive impact on digital entrepreneurial activity

Digital technology constitutes a cornerstone of entrepreneurial opportunity both as an outcome and as part of the process. Digital technologies such as social media and data analytics offer the tools for opportunity recognition (Nambisan, 2017). Information asymmetry and prior related knowledge largely determine the opportunity discovery and identification of the individual entrepreneur (Cirulli et al., 2016) and it opens a greater variety of positioning options to the firms in order to exploit future opportunities as they emerge (Sambamurthy et al., 2003). Prior related knowledge refers, either to knowledge on some special interest, or to industry specific knowledge of the entrepreneur. A continuous processing of prospective opportunities takes place based on the entrepreneur's prior related knowledge, where the convergence of special interest knowledge with industry knowledge increases the stakes for successful venture startup (Ardichvili et al., 2003). Relevant technical knowledge gained through education and training, is essential human capital with a significant impact on the development of opportunity and business success (Marvel et al., 2016). Digital technology is considered an enabling factor for digital entrepreneurial activity (Kreuzer et al., 2022; Shepherd et al., 2021), through its impact on the cognitive ability and the behavior of the entrepreneur (Kreuzer et al., 2022). Therefore, it is important to understand how it influences opportunity recognition competence (Nambisan, 2017; Steininger, 2019; von Briel et al., 2018b).

Hypothesis 2

H2. IT knowledge is a positive predictor of Opportunity competence

Entrepreneurial knowledge is a key factor for the development of student entrepreneurship (Scuotto and Morellato, 2013). Entrepreneurial program learning acquired from

entrepreneurship courses plays a major role on opportunity identification (Morris et al., 2017; Souitaris et al., 2007), especially for technology majors (Zhang et al., 2014).

Hypothesis 3

H3. Entrepreneurial program learning has a positive impact on Opportunity competence

Entrepreneurship Education and Entrepreneurial program learning

Entrepreneurship education, transfers the necessary knowledge and skills to those willing to chase opportunities, innovate and become entrepreneurs (Kirby and Ibrahim, 2011). Consequently, entrepreneurship education is responsible for the cultivation of the entrepreneurial mindset of students which is required for the development of entrepreneurial activity and it moderates the role of environmental factors on entrepreneurial intentions (Bergmann et al., 2018; Entrialgo and Iglesias, 2016). Entrepreneurial courses are nowadays offered in a great variety of scientific disciplines in universities worldwide (Kakouris and Liargovas, 2020). The majority of students who took part in GUESSS 2016 survey, declared some benefit from the courses they had attended (Sarri and Laspita, 2016). A significant positive relation was found between Entrepreneurial knowledge and two TPB constructs, namely Personal Attitude and Perceived Behavioral Control, but, only an indirect effect was found on entrepreneurial intention through these constructs (Yaghoubi Farani et al., 2017). Entrepreneurship scholars are in a debate concerning the impact of entrepreneurship courses on students' intentions to start new business due to conflicting results (do Paço et al., 2013; Marques et al., 2012; Oosterbeek et al., 2010; Sitaridis and Kitsios, 2017). Students' self-perceptions of entrepreneurial program learning are a reliable measure of entrepreneurship courses effectiveness (Souitaris et al., 2007). These perceptions regarding students' abilities and skills developed during entrepreneurship courses, have been used for course evaluation by previous research (Sitaridis and Kitsios, 2019b). Entrepreneurial knowledge obtained through entrepreneurship programs can improve students' attitudes and motivation and develop their practical skills, such as intuition for opportunity recognition, collaboration, steps for firm creation process and access to professional networks (Souitaris et al., 2007), while it has also a positive impact on entrepreneurial intentions (Sitaridis and Kitsios, 2023b). Although typical entrepreneurship courses accomplish that to a certain extent determined by previous entrepreneurial experience, entrepreneurship education pedagogy and contextual factors (Hahn et al., 2017), the transfer of entrepreneurial experience through action oriented learning approaches is has a pivotal role on new venture creation (Pittaway and Cope, 2007). Entrepreneurial program learning can help entrepreneurship educators identify students'

groups that benefit the most out of their courses, highlight course design inefficiencies and help improve the effectiveness of entrepreneurship programs.

Hypothesis 4

H4a. Entrepreneurial program learning has a positive impact on digital entrepreneurial intention

H4b. Entrepreneurial program learning has a positive impact on digital entrepreneurial activity

IT knowledge and Computer Self-efficacy

The value of IT in contemporary entrepreneurship is widely recognized nowadays, since IT is the key component in business process transformation through the digitalization of business model. Digital entrepreneurs seek market opportunities which can be exploited by means of the latest IT technology. IT technology maturity serves as a driver of entrepreneurial perceptions driving e-business opportunity recognition and digital business transformation (Zhu and Lin, 2019). IT capabilities have a positive influence on a firm's product innovation performance and overall corporate entrepreneurship (Chen et al., 2015). Radical Innovation in technology entrepreneurship is directly related to prior IT knowledge (Marvel and Lumpkin, 2007). University students develop entrepreneurial intentions and entrepreneurial implementation intentions during their studies, which potentially creates subsequent entrepreneurial behavior (Mir et al., 2022). IT entrepreneurial intentions are determined by their technology skills and personal innovativeness in IT, according to previous research (Chen, 2014; Zenebe et al., 2018).

Additionally, IT knowledge and experience are positive predictors of Computer Self-efficacy (He and Freeman, 2010), which in turn has a positive relation with entrepreneurial intention.

Hypothesis 5

H5a. IT knowledge has a positive impact on digital entrepreneurial intention

H5b. IT knowledge has a positive impact on digital entrepreneurial activity

H5c. Computer Self-Efficacy has a positive impact on digital entrepreneurial intention

H5d. Computer Self-Efficacy has a positive impact on digital entrepreneurial activity

Conceptual Model

The conceptual model of the analysis is shown in Figure 6. The relations between constructs were examined using Structural Equation Models (SEM).

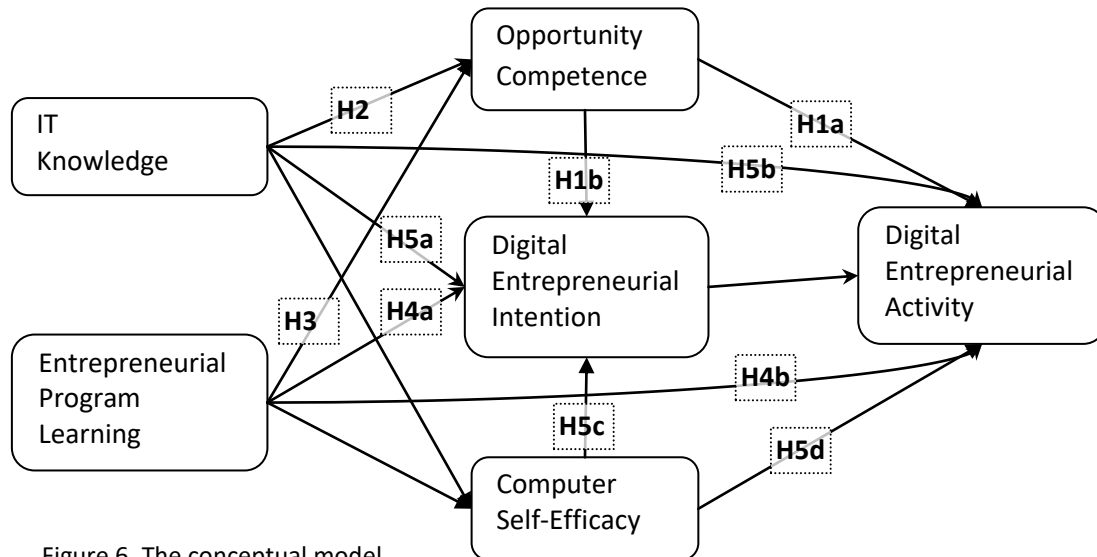


Figure 6. The conceptual model

3.2. Research Design

An invitation to participate was sent by email to approximately 1500 University students, 23.4% of which were attending IT related disciplines. The survey link was included in an invitation email explaining the nature and significance of the research, as well as, anonymity and privacy protection precautions. A total of 467 anonymous usable responses were received.

Measures

The participants were asked to rate themselves on each item associated with the variables studied in the aforementioned research model. For the measurement of Digital Entrepreneurial Intention (DEI), 4 items originally developed for the Entrepreneurial Intention Questionnaire by (Liñán and Chen, 2009). These items were modified accordingly for digital entrepreneurship and have been successfully tested in previous study (Sitaridis and Kitsios, 2023b). Sample items of this scale include: 'I am determined to start a digital business', 'My professional goal is to become a digital entrepreneur', 'I have very seriously thought of starting a digital business'. Entrepreneurial Program Learning (EPL) was measured

using a scale consisting of 4 items, accordingly modified to determine students' perceptions regarding digital entrepreneurship related outcomes of entrepreneurship courses. EPL has been used in a previous study as a proxy for accumulated knowledge during an entrepreneurial courses (Sitaridis and Kitsios, 2023b). Questionnaire items examining the Program Learning include: 'My courses helped me develop original business ideas for a digital startup', 'My courses helped me develop the required leadership and communication skills required to get involved with digital entrepreneurship', 'My courses helped me develop knowledge and skills required for a digital startup', 'My courses offered me valuable experience from real digital business situations', based on the perceptual measures originally developed and validated by Souitaris *et al.*, (2007). For the measurement of IT knowledge a total of 9 items were used, found in Zenebe *et al.*, (2018). Sample items include: 'I have an excellent knowledge of hardware components of computers'; 'I have a very poor knowledge of operating software components of computers'; 'I have an excellent knowledge of application software components of computers; I have an excellent knowledge of database technology'; 'I have an excellent knowledge of communication and network technologies'. The benefit of the scale is that it is not limited to specific topic of IT and concerns a wide range of knowledge from basic to more specialized issues. Opportunity Competency was measured using 3 items from (Tehseen et al., 2020). Sample items include 'I sought high quality business opportunities', 'I take an idea or concept and make something out of it', 'I scan the environment to explore opportunities'. Computer Self-efficacy (CSE) was measured using 4 items from Compeau and Higgins, (1995). These items have been used in previous study examining the effect of CSE on students' EI through the TPB variables (Sitaridis and Kitsios, 2019c). Sample items include 'I could complete a task using a new computer software if there was no one around to tell me what to do', 'I could complete a job using a new computer software if I had never used a package like it before'. Finally, for entrepreneurial activity was measured using 8 items used in past GUESSS/GEM/PSED surveys for gestation activities (Bosma et al., 2008; Sarri and Laspita, 2016), modified accordingly for digital entrepreneurship. Gestation activities have been used as a proxy of entrepreneurial activity by previous research (Kautonen et al., 2015), as they indicate substantial steps in nascent venture creation procedure, which can reliably predict future survival and profit (Sousa et al., 2019; Zapkau et al., 2017). Moreover the number of gestation activities undertaken by the nascent entrepreneur reflects on the later nascent venture success (Zaheer et al., 2019b). Sample items for gestation activities include: 'I have (1) developed a business plan; (2) developed a product or service; (3) discussed with

potential customers; (4) made step to form a team; (5) applied for a patent or copyright; (6) made contacts to obtain funding; (7) purchased equipment, or software; and (8) already registered a business'. The variables used in the questionnaire are summarized in Table 3.

Table 3. Variables and definitions

<i>Variable</i>	<i>Definition</i>
Digital Entrepreneurial Intention (DEI)	Entrepreneurial intention indicates the effort that an individual would make to establish a new venture (Liñán and Chen, 2009), the commitment to start a new business (Krueger, 2009), the individual's decision for a new venture creation made before examining practical opportunities (Esfandiar et al., 2019) Digital Entrepreneurial Intention indicates the commitment and effort an individual is willing to take over in order to create a new digital venture (Sitaridis and Kitsios, 2023b).
Entrepreneurial Program Learning (EPL)	Entrepreneurial Program Learning refers to the entrepreneurial knowledge students acquire during Entrepreneurship Programs, including values, motivation, knowledge, skills, social skills, experience and intuition (Souitaris et al., 2007).
Computer Self-efficacy (CSE)	Computer Self-Efficacy represents an individual's perceptions of his or her ability to use computers in the accomplishment of a task (Compeau and Higgins, 1995). CSE is an IT specific individual trait, derived from Self-Efficacy, that refers to the personal perception of the individual, regarding the ability to perform certain computer tasks (Sitaridis and Kitsios, 2019c)
IT knowledge	Perceived knowledge level of the individual regarding IT technology commonly used in business applications (Zenebe et al., 2018) A human capital concept representing accumulated IT technology related knowledge and experience (Sitaridis and Kitsios, 2023b)
Gestation activities	Activities already completed by nascent entrepreneurs (Bosma et al., 2008; Sarri and Laspita, 2016)
Opportunity Competency (OPC)	The entrepreneur's ability to envision market opportunities, the awareness of customers' demands (Tehseen et al., 2020)

All questionnaire items were rated on a 5 point Likert scale between (1) 'Fully disagree' and (5) 'Fully agree'. Control variables were also used in the analysis. Gender, coded as Female=1, Male=2, plays an important role on students' entrepreneurial intentions (López-Delgado et al., 2019). Year of study was also considered in the analysis, since students develop stronger entrepreneurial intention at the end of their studies (Kakouris, 2016). Students were divided in different age groups were coded as '18-24' =1, '25-34'=2, '35-44'=3, '45-55'=4, '55+'=5. Finally, parent entrepreneurial role model was accounted for (Yes= 1,

No= 0), since students with self-employed parents show increased entrepreneurial tendency (Laspita et al., 2023).

The full questionnaire can be found in Appendix B.

3.3. Analysis

Sample description

The demographics of the sample are shown in Table 4. The sample consists of 56.1% female students and 43.9% male students. Most of the respondents were undergraduates (87.4%), between 18 and 24 years old (83.9%). A 41.5% of the students had parental entrepreneurial role models in their family. Moreover, 73.4% were attending IT related majors, whereas 51.4% had attended one or more entrepreneurship courses.

Table 4. Sample statistics

<i>Demographic groups</i>	<i>Coding</i>	<i>Number of students</i>	<i>Percentage %</i>
<i>Students Gender</i>			
Male	2	262	43.9
Female	1	205	56.1
<i>Parent entrepreneur</i>			
No	0	273	58.5
Yes	1	194	41.5
<i>Students Age</i>			
18-24	1	392	83.9
25-34	2	46	9.9
35-44	3	18	3.9
45-55	4	9	1.9
55+	5	2	0.4
<i>Students Study level</i>			
Graduate	1	408	87.4
Postgraduate	2	59	12.6
<i>Students Year of studies</i>			
1 year	1	230	49.3
2 years	2	48	10.3
3 years	3	82	17.6
4 years	4	66	14.1
5 years or more	5	41	8.8
<i>Entrepreneurship Courses</i>			
None	0	93	19.9
1	1	134	28.7
2 or more	2	240	51.4
<i>IT related discipline</i>			
No	0	124	26.6
Yes	1	343	73.4
N		467	100.0

Results

All factor items for DE Intention, IT knowledge and Program Learning, were averaged into composite measures, which were used in the subsequent analysis (Hair et al., 2009). The sample exceeded the minimum size requirements and the assumption for normality was met on the basis of moderate data skewness and kurtosis within the recommended ± 1.5 range (Schumacker and Lomax, 2010). The normality of measures is graphically depicted by the normality curves shown in Figure 7 and Figure 8.

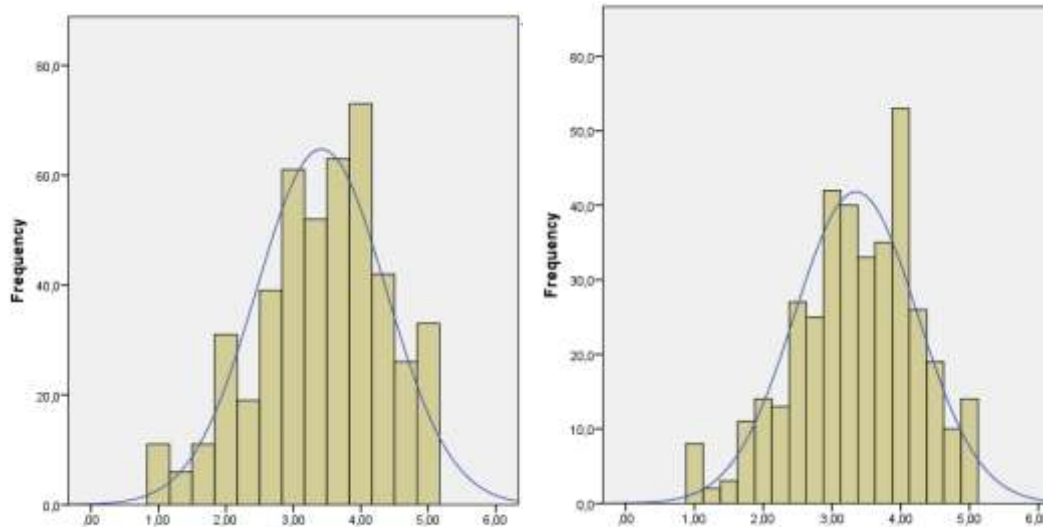


Figure 7. Normality curves for OPC and EPL

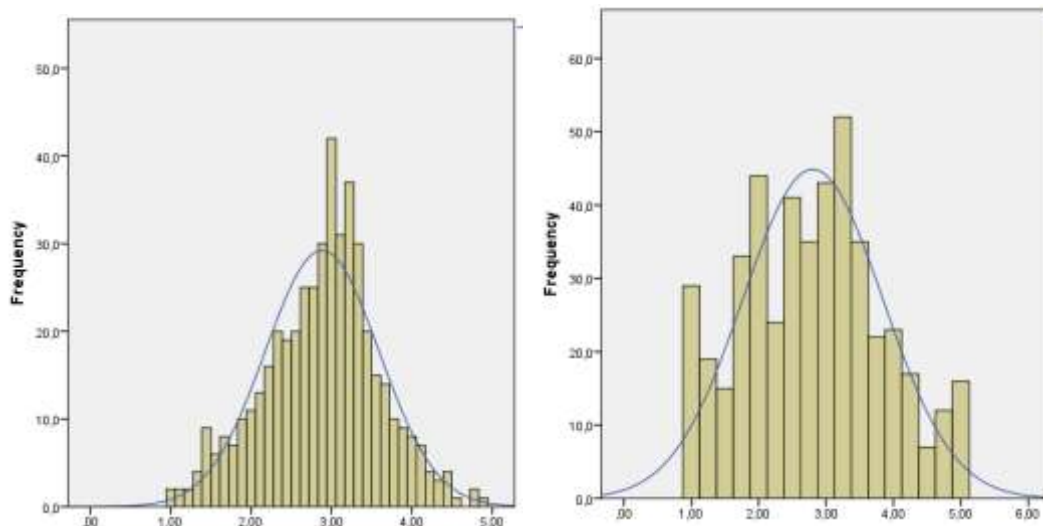


Figure 8. Normality curves for IT Knowledge and DEI

The descriptive statistics of the control variables and the composite measures are shown in Table 5.

Table 5. Descriptive statistics

<i>Variable</i>	<i>N</i>	<i>Min</i>	<i>Max</i>	<i>Mean</i>	<i>Std deviation</i>
Gender	467	1	2	1.56	.497
Age	467	1	5	1.25	.658
Parent entrepreneur	467	0	1	0.42	.493
Study level	467	1	2	1.13	.333
Years of study	467	1	5	2.23	1.405
Entrepreneurship Courses	467	0	2	1.31	0.784
DE Intention	467	1	5	2.80	1.038
IT knowledge	467	1	5	2.88	.708
Program learning	375	1	5	3.34	.894
Computer Self-Efficacy	467	1	5	3.77	.848
Opportunity Competence	467	1	5	3.41	.959
DE Activity	467	0	7	0.42	.979

Table 6 presents the reliability statistics. All constructs show increased internal consistency with reliability coefficients well above the minimum requirement of Cronbach's $\alpha > 0.7$ (Hair et al., 2009).

Table 6. Reliability statistics

<i>Construct</i>	<i>Cronbach's alpha</i>	<i>Number of items</i>
DE intention	.899	4
IT knowledge	.798	9
Program learning	.839	4
Computer Self-efficacy	.829	4
Opportunity Competence	.828	3

Three different models were tested. Model 1 examined the effects of EPL and IT-Knowledge on DE Intention and DE Activity, whereas Model 2 additionally included CSE and Model 2 included also OPC as mediators. The fit indices of the three models are shown in Table 7. All models exhibited satisfactory fit, based on the guidelines found in SEM literature (Hoyle, 2012; Jackson et al., 2009).

Table 7. Fit indices

<i>Goodness of fit</i>	<i>Indices</i>	<i>Optimal value</i>	<i>Model1</i>	<i>Model2</i>	<i>Model3</i>
Absolute fit	Chi-square	p-value >0.05	313.44 (<i>p</i> =0.00)	375.13 (<i>p</i> =0.00)	739.80 (<i>p</i> =0.00)
	Df		162	216	279
	GFI	>0.90	0.93	0.93	0.92
	SRMR	<0.08	0.04	0.05	0.06
	RMSEA	<0.06	0.05	0.04	0.04
Incremental fit	AGFI	>0.90	0.89	0.89	0.89
	TLI	>0.90	0.93	0.91	0.94
	CFI	>0.90	0.95	0.94	0.96
Parsimony measures	PNFI		0.63	0.65	0.67
	PCFI		0.67	0.69	0.71
	AIC		495.44	643.13	715.59

From the SEM results for Model 1 (in Figure 9), shown in Table 8, we conclude that EPL and IT-Knowledge, both have statistically significant positive impact on DEI, with EPL having a stronger influence than IT ($b_{PL_DEI}=.35^{***}$, $b_{IT_DEI}=.17^{**}$). DEI on the other hand has a significant direct effect on DEA ($b_{DEI_DEA}=.31^{**}$). However, DEA is not directly affected by EPL and IT, since the effects are both statistically insignificant ($b_{EPL_DEA}=.08$, $b_{IT_DEA}=-.06$).

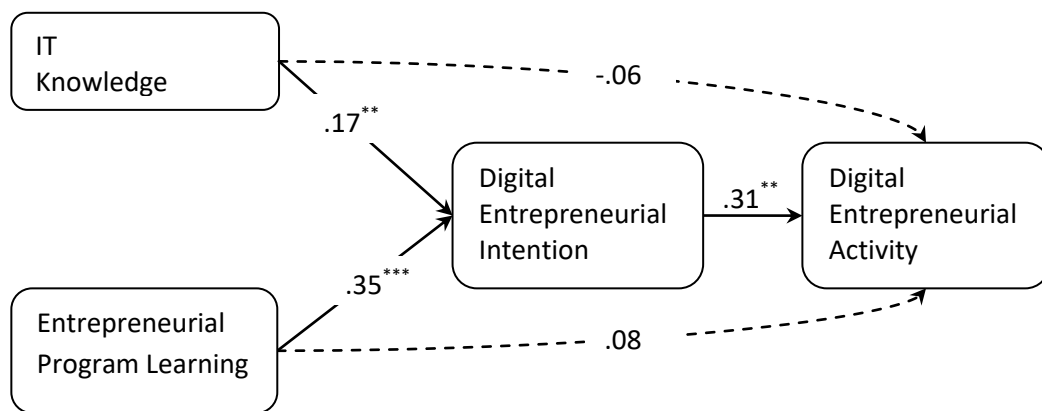


Figure 9. Model 1

(*** <0.01, ** <0.05)

The results for Model 2, shown in Figure 10, including additionally the CSE variable are presented in Table 8. It is evident that EPL retains a stronger direct and statistically significant total effect on DEI ($b_{EPL_DEItot}=.41^{***}$). On the other hand, the total effect of EPL on DEA is not statistically significant ($b_{EPL_DEAtot}=.06$).

The total effect of IT-Knowledge on DEI is still statistically significant ($b_{IT_DEItot}=.12^{***}$), and the total effect of IT on DEA becomes positive and statistically significant ($b_{IT_DEAtot}=.10^{***}$). IT-Knowledge also has a strong positive impact on CSE ($b_{IT_CSEtot}=.58^{***}$). However, the total effect of CSE on DEI is statistically insignificant ($b_{CSE_DEItot}=.06$), and also no indirect effect on DEI is present ($b_{CSE_DEIind}=.02$). The total effect of CSE on DEA is also not statistically significant ($b_{CSE_DEAtot}=.16$) and there is also no indirect impact on DEA ($b_{CSE_DEAind}=.02$).

Finally, DEI exhibits a strong positive direct effect on DEA ($b_{DEI_DEA}=.37^{***}$).

Table 8. Structural Model Results

Predictor	Outcome	Model 1	Model 2			Model 3		
		<i>b</i>	<i>b</i>	<i>Direct</i>	<i>Indirect</i>	<i>b</i>	<i>Direct</i>	<i>Indirect</i>
EPL	DEI	0.35 ^{***}	0.41 ^{***}	0.41 ^{***}	0.01	0.38 ^{***}	0.13	0.24 ^{***}
IT	DEI	0.17 ^{**}	0.12 ^{***}	0.09	0.04	0.16 ^{***}	0.09	0.07 ^{***}
CSE	DEI	-	0.06	0.06 ^{***}	-	0.07	-0.06	0.16 ^{***}
OPC	DEI	-	-	-	-	0.59 ^{***}	0.59 ^{***}	-
IT	CSE	-	0.58 ^{***}	0.58 ^{***}	-	0.57 ^{***}	0.57 ^{***}	-
IT	OPC	-	-	-	-	0.19 ^{***}	0.06	0.13 ^{***}
IT	DEA	0.08	0.10 ^{***}	-0.02	0.12 ^{***}	0.13 ^{***}	0.05	0.12 ^{***}
EPL	CSE	-	0.11 ^{***}	0.11 ^{***}	-	0.11 ^{***}	0.11 ^{***}	-
EPL	OPC	-	-	-	-	0.47 ^{***}	0.44 ^{***}	0.03 ^{***}
EPL	DEA	-0.06	0.06	-0.01	0.17 ^{***}	0.07	-0.11 ^{***}	0.17 ^{***}
CSE	DEA	-	0.16	0.13	0.02	0.16	0.10	0.06
OPC	DEA	-	-	-	-	0.33 ^{***}	0.18 ^{***}	0.17 ^{***}
DEI	DEA	0.31 ^{***}	0.37 ^{***}	0.37 ^{***}	-	0.29 ^{***}	0.29 ^{***}	-

*Dependent variable: DEI, *** <0.01, ** <0.05*

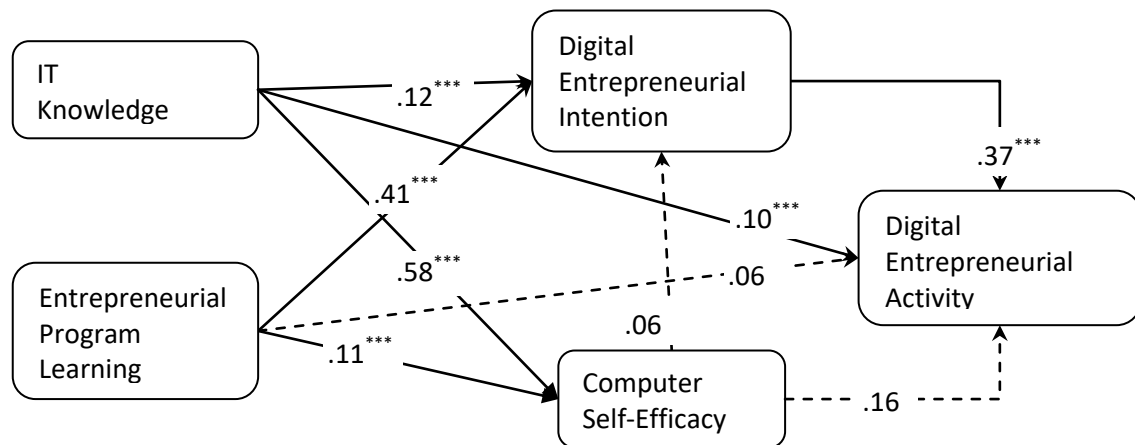


Figure 10. Model2 – Total effects

(*** <0.01, ** <0.05)

The results for Model 3, shown in Figure 11, demonstrate a statistically significant total effect of EPL on DEI ($b_{EPL_DEItot}=.38^{***}$), although the direct effect EPL on DEI is statistically insignificant ($b_{EPL_DEIdir}=.13$). On the other hand, the total effect of EPL on DEA is not statistically significant ($b_{EPL_DEAtot}=.07$). The total effect of IT-Knowledge on DEI is still statistically significant ($b_{IT_DEItot}=.16^{***}$), as well as the total effect of IT on DEA ($b_{IT_DEAtot}=.13^{***}$). IT-Knowledge also exerts strong positive impact on CSE ($b_{IT_CSE}=.57^{***}$). However, CSE has only indirect effect on DEI ($b_{CSE_DEIind}=.16^{***}$), whereas it has not got significant impact on DEA, directly or indirectly. OPC, on the other hand has a statistically significant positive impact on ($b_{OPC_DEItot}=.59^{***}$), as well as on DEA ($b_{OPC_DEAtot}=.33^{***}$). Finally, DEI maintains the positive direct effect on DEA ($b_{DEI_DEA}=.29^{***}$). The variables under examination also exhibit various indirect dependencies as it is evident from the analysis results shown in Table 8.

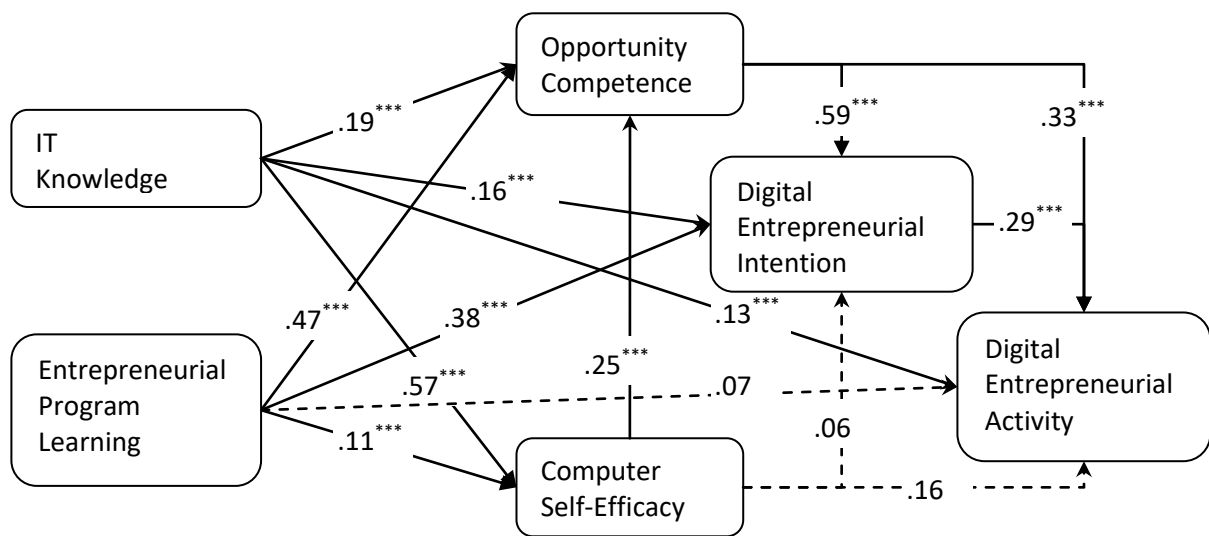


Figure 11. Model3 – Total effects

(*** <0.01, ** <0.05)

4. Discussion

The study examines the important role of IT-Knowledge on the formation of DE Intentions and further on actual DE Activity. This study is the first to the best of our knowledge, to combine motivational theory constructs with human capital theory constructs and propose a complex theoretical model, including Entrepreneurial Program Learning as predictor, Computer Self-Efficacy and Opportunity Competency as mediators, and DE Intentions and DE Activity as outcome variables.

Regarding Hypotheses 1a and 1b, it is confirmed from the results of Model2 and Model3, that Opportunity Competency has a strong positive impact both on students' DE Intention and DE Activity. This result is in consistency with the significant positive relation between opportunity alertness and entrepreneurial inspiration suggested by previous studies (Cui et al., 2021; Esfandiar et al., 2019), and positive indication of a well developed entrepreneurial mindset (Karimi et al., 2016).

Regarding Hypothesis 2, based on Model 3 results, it is evident that IT-Knowledge, is a considerable predictor of students' opportunity recognition. This result is in consistency with the findings of (Zenebe et al., 2018). Additionally, a both the witnessed significant impact of IT knowledge and CSE on opportunity competence, is consistent with the suggestions of previous studies (Albashrawi and Alashoor, 2020; Chou *et al.*, 2017; Sitaridis and Kitsios, 2019b).

Regarding the impact of Entrepreneurial Program Learning on Opportunity Competency, it can be concluded, based on the results of Model 3, that it has a powerful positive effect, which means that the participation of students in Entrepreneurship courses significantly increases their ability to capture business opportunities. This finding offers support to Hypothesis 3 and it is therefore in concordance with previous studies (Carpenter and Wilson, 2022; Cui et al., 2021; Morris et al., 2017; Rodriguez and Lieber, 2020).

Regarding the hypothesized effect of Entrepreneurial Program Learning on DE Intention, the results of all three models tested, namely Model1, Model2 and Model 3, offer support to Hypothesis H4a, in line with previous research (Sitaridis and Kitsios, 2023b; Souitaris et al., 2007).

However, Hypothesis H4b, suggesting a positive effect of Entrepreneurial Program Learning on DE Activity, was not confirmed. The total effect of EPL on DEA is statistically insignificant, suggesting that knowledge offered in Entrepreneurship courses is not a valid predictor of actual Entrepreneurial activity in the digital space.

On the other hand, IT-Knowledge has a weaker effect on DE Intention, compared to that of EPL, which confirms hypothesis H5a and is in symphony with previous research suggesting that IT-Knowledge is a driver of DEI (Mir et al., 2022; Sitaridis and Kitsios, 2023b; Zenebe et al., 2018). Most importantly, IT-Knowledge, based on the results of Model 2 and Model 3, has a positive impact on DE Activity. Therefore Hypothesis H5b, claiming that specialized IT-Knowledge offered in IT related disciplines is a valid determinant of DE Activity, is fully supported in consistency with previous research associating IT knowledge with entrepreneurial behavior intention (Mir et al., 2022; Zenebe et al., 2018). These findings confirm that specific IT-knowledge taught in IT related disciplines not only tenders the development of the individual's general feeling regarding their ability to successfully use computer software, but also nurtures DE Intentions and drives DE Activity.

Finally, the effect of IT-Knowledge on Computer Self-Efficacy is also positive and statistically significant, consistent with the work of (Sitaridis and Kitsios, 2023b, 2019c). Contrary though to Hypotheses 5c and 5d, the expected positive impact of CSE either on DEI or on DEA was not confirmed by the results of Model2 and Model3. This finding is in line with previous research, that examined the effect of CSE on DEI in isolation from other constructs (Sitaridis and Kitsios, 2019c), suggesting that CSE is rather affecting DEI through the motivational constructs of the TPB than acting directly on intentions. Albashrawi and

Alashoor, (2020), have similarly found only indirect effect of CSE on EI through the TPB motivational construct of Personal Attitude. However, the findings are in contrast to those of Chou *et al.*, (2017), who found a significant impact of CSE on EI, which might be explained by their choice to use different measurement scales, based on computer software playfulness, autonomy and usefulness, than the original measures proposed by Compeau and Higgins, (1995). The results for all hypotheses are summarized in Table 9.

Table 9. Hypothesis testing

<i>Hypothesis</i>		<i>Effect</i>	<i>Result</i>
H1a	Opportunity competence has a positive impact on digital entrepreneurial intention	OPC→DEI	True
H1b	Opportunity competence has a positive impact on digital entrepreneurial activity	OPC→DEA	True
H2a	IT knowledge is a positive predictor of Opportunity competence	IT → OPC	True
H3	Entrepreneurial program learning has a positive impact on Opportunity competence	EPL→OPC	True
H4a	Entrepreneurial program learning has a positive impact on digital entrepreneurial intention	EPL→DEI	True
H4b	Entrepreneurial program learning has a positive impact on digital entrepreneurial activity	EPL →DEA	False
H5a	IT-Knowledge has a positive impact on digital entrepreneurial intention,	IT →DEI	True
H5b	IT-Knowledge has a positive impact on digital entrepreneurial activity	IT →DEA	True
H5c	Computer Self-Efficacy has a positive impact on digital entrepreneurial intention	CSE→DEI	False
H5d	Computer Self-Efficacy has a positive impact on digital entrepreneurial activity	CSE→DEA	False

5. Conclusions

Opportunity competency is a fundamental prerequisite for the entrepreneurial activity. Digital technology, is considered an enabling factor for opportunity recognition, due to its invasiveness and its ability to blare boundaries between industry and product, as well as boundaries between customer and firm (Kreuzer et al., 2022). Although, a positive impact of IT-Knowledge on opportunity recognition, seems to be straightforward nowadays (von Briel et al., 2018a), the exact mechanism of its impact on the development of entrepreneurial activity in the digital domain has not been thoroughly investigated (Kreuzer et al., 2022). Additionally, although IT-Knowledge and proficiency in use of computer applications are considered important for the development of entrepreneurial activity (Zenebe et al., 2018), this relation has not been thoroughly examined in the context of DE, and the few existing studies are inconclusive (Redondo-Rodríguez et al., 2023). Rapid changes in digital technology force quick responses from educational institutions, in order to adapt to trending digital skills required by the emerging key digital technologies, necessary for DE, while feedback availability on the efficiency of their efforts is generally limited (Redondo-Rodríguez et al., 2023). In this regard, more empirical research is required firstly to define important IT-related factors influencing entrepreneurial cognition of actors (Kreuzer et al., 2022), and secondly, to define an informed DE Intention theoretical model unifying human capital and intentional theoretical perspectives (Hindle et al., 2009). This paper addresses the issue by examining the role of two self-reporting human capital related constructs, namely, Computer Self-Efficacy and specific IT-Knowledge on Digital Entrepreneurial Intentions of university students. Additionally, the effect of the aforementioned constructs on DE activity is examined. Another novelty of the proposed theoretical model, is that it examines the role of IT-Knowledge, in combination with Opportunity Competency and Entrepreneurial program Learning. The results confirm the specific IT-Knowledge offered in IT related departments has a significant positive impact not only on DE Intentions of students, but it also increases the possibilities for students to get involved with DE Activity. Moreover, good level of IT-Knowledge offers increased ability of Opportunity Identification. While Entrepreneurial Program Learning and Computer Self-Efficacy, two constructs frequently studied in the literature, confirm their significant positive effect on DE Intention and Opportunity Competence, IT-Knowledge is the only construct in the model that has a direct impact on DE Activity. Opportunity Competence on the other hand has a positive effect both on DE Intention and DE Activity. Therefore, it becomes evident that entrepreneurial knowledge and general ability of using computer applications alone are not

enough to turn student's intentions into actions, and support them in making actual steps towards starting a digital business. Based on the findings, the deeper understanding of IT technology, obtained through courses offered in the typical curriculum of IT related disciplines, plays a more important role for the development of digital entrepreneurial activity. These findings are consistent with the argument that digital knowledge and skills are important elements of digital entrepreneurial activity (Redondo-Rodríguez et al., 2023).

Theoretical implications

This research contributes to theory in two ways. Firstly, it offers a representative picture of the topic of DE in the literature review section, it synthesizes literature from different disciplinary origins, and provides linkages between unconnected streams of research. Additionally, it highlights current trends of research in the field, and points out various research gaps. Finally it proposes a conceptual framework which is the first (to the best of our knowledge) to circumscribe DE education as a field of study and may serve as a roadmap for future research. Secondly, it offers an explanation on the impact of Digital Technology both on intentions and nascent activity towards entrepreneurship development in the digital domain. The paper answers the call of von Briel *et al.*, (2021), for further research in theoretical approaches examining the contribution of digital technology, as well as other influential factors on individual's opportunity identification ability (Nambisan, 2017; Steininger, 2019). Another novelty of the paper is the combination of different theoretical perspectives, that of human capital theory, with that of motivational theories examining both entrepreneurial and technical knowledge required in a digital venture, in order to explain intentions and examine their consequences for actions. The rationale behind the adopted methodology is to provide the opportunity to develop an 'informed' EI theoretical model, explaining behavioral intentions based on knowledge, information and guidance obtained through processes of the social environment, including education and social interaction (Hindle et al., 2009). Additionally, this work answers the call for more empirical research to substantiate and increase our predictive ability on how knowledge of digital technology acts on opportunity identification and drives subsequent DE initiatives, which would allow the further study of success factors for DE (Kreuzer et al., 2022). Finally, the paper sheds light on the link between intentions and actions, highlighting the important mediating role of IT-Knowledge and opportunity identification ability (Meoli et al., 2020).

Practical implications

Many students nowadays attend either compulsory or elective entrepreneurship courses in their universities. These courses improve students' entrepreneurial attitudes and increase entrepreneurial intentions. However, little proof exists on the link between intentions and entrepreneurial activity and scholars call for further research (Meoli et al., 2020; Mir et al., 2022). The results offer sound empirical proof on the relation of DE Intentions to nascent DE activity. Moreover, IT-Knowledge appears to be an important influential factor both for DE intentions and DE activity. This effect occurs through multiple routes, improving both opportunity identification competence, as well as computer self-efficacy. Based on these findings, entrepreneurship education, needs not only to focus on entrepreneurial knowledge and skills, in order to foster DE activity among students, but needs also to examine new educational approaches, such as design thinking in order to offer entrepreneurial knowledge in a less traditional way, enriched with digital competences and specific IT-knowledge, which are important for DE activity (Redondo-Rodríguez et al., 2023; Youssef et al., 2021). Graduate students and existing entrepreneurs frequently possess rich entrepreneurial background, yet they lack up to date digital knowledge regarding the latest advances in emerging digital technologies and this can impede the launch of digital business (Redondo-Rodríguez et al., 2023; Sousa et al., 2019). Therefore, universities need to design fast track courses to cover the needs of this target group, interested in starting a digital business, providing them with the necessary and up to date IT-knowledge for a successful startup. On the other hand, collaboration of students with successful digital business representatives through digital learning platforms can foster the knowledge exchange and develop digital academic entrepreneurship (Linzaone et al., 2020). Finally, policy makers should examine the possibility to provide legal status and facilitate student digital entrepreneurship (Youssef et al., 2021). Such an approach would benefit DE activity, since in this case prospective students digital entrepreneurs would take advantage of the everyday support and coaching from experienced university staff, and would result in flourishing digital entrepreneurial ecosystems within universities.

Limitations and proposals for future research

This research is not without limitations. One limitation is that only self-perception measures were used to examine the variables of interest. Such measuring items have been criticized in the past. A large share of the students in the sample has attended compulsory or elective entrepreneurship courses, which might indicate some self-selection bias. Also large

part of the sample consists of students with IT related graduate or postgraduate background studies, which might also bias the results. The sample size is also limited, while only two universities are represented in the sample also. Future research should examine larger samples including students from different backgrounds, coming from a larger number of universities. Group differences should be also examined between genders, disciplines, levels of studies etc. The universities represented in the sample come from the same country, so it is impossible to examine possible influence of culture in the results. Since entrepreneurial intentions and choices of students are differentiated between cultures (Laspita et al., 2023), a multi-culture research design could very useful to examine differences between different cultures (Youssef et al., 2021). Additionally, IT-knowledge measure scale is limited to general IT-Knowledge and does not include items examining knowledge and skills related with the latest emerging technologies. Future research should examine specific IT-Knowledge required in fields of DE, related to emerging digital technologies such as AI, VR etc.

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Appendix A: Table of Articles

Table 10. Final set of articles in the sample by conceptual dimension

<i>Main Dimensions</i>	<i>Sub-streams</i>	<i>Articles</i>
Pedagogy and learning dimension	ICT dominance in business (16)	(Allen, 2020; Carrier <i>et al.</i> , 2004; Clarke and Clarke, 2009; Dhar and Sundararajan, 2007; Del Giudice and Straub, 2011; Giuggioli and Pellegrini, 2022; Kang and Lee, 2020; Kollmann <i>et al.</i> , 2022; Lamine <i>et al.</i> , 2021; Matlay, 2004; Nambisan, 2017; Nzembayie <i>et al.</i> , 2019; Ratten and Usmanij, 2021; Rof <i>et al.</i> , 2020; Steininger, 2019; Zaheer, Breyer and Dumay, 2019)
	Learning approaches (16)	(Androutsos and Brinia, 2019; Chang, Hsiao, <i>et al.</i> , 2018; Daly, 2001; Le Dinh <i>et al.</i> , 2018; Jones and Lau, 2010; Laptev and Shaytan, 2022; Millman <i>et al.</i> , 2009; Monllor and Soto-Simeone, 2020; Morris and König, 2021; Pereira <i>et al.</i> , 2020; Rohm <i>et al.</i> , 2021; Secundo <i>et al.</i> , 2021; Secundo, Rippa and Meoli, 2020; Shurville and Rospigliosi, 2009; van der Westhuizen and Goyayi, 2020; Zhang, 2014)
	Digital Learning Environments (11)	(Carenys and Moya, 2016; Cirulli <i>et al.</i> , 2016; Huebscher and Lendner, 2010; Linzalone <i>et al.</i> , 2020; Ratten, 2020; Rayna and Striukova, 2021; Sun, 2020; Thanachawengsakul and Wannapiroon, 2021; Vorbach <i>et al.</i> , 2019; Wang and Chiou, 2020; Žur, 2020)
Success factors and barriers dimension	Enabling factors (5)	(Chae and Goh, 2020; Kraus <i>et al.</i> , 2019; Ladeira <i>et al.</i> , 2019; Shimoli <i>et al.</i> , 2020; Zaheer, Breyer, Dumay, <i>et al.</i> , 2019)
	Constrains (1)	(Muafi <i>et al.</i> , 2021)
Behavioral Dimension	Personality (4)	(Ashraf <i>et al.</i> , 2021; Chang <i>et al.</i> , 2020; Wang <i>et al.</i> , 2016; Yeh <i>et al.</i> , 2020)
	Motivational factors (15)	(Alzamel <i>et al.</i> , 2020; Batool <i>et al.</i> , 2015; Chang, Wang, <i>et al.</i> , 2018; Chen, 2013, 2014; Ferreras-Garcia <i>et al.</i> , 2019; Ghatak <i>et al.</i> , 2020; Mancha and Shankaranarayanan, 2021; Mand <i>et al.</i> , 2018; Millman <i>et al.</i> , 2010; Siriattakul and Jermsittiparsert, 2019; Wang <i>et al.</i> , 2020; Yaghoubi Farani <i>et al.</i> , 2017; Youssef <i>et al.</i> , 2021; Zenebe <i>et al.</i> , 2018)
Ecosystems dimension	Ecosystems (9)	(Birch <i>et al.</i> , 2017; Elia <i>et al.</i> , 2020; Galanakis and Giourka, 2017; Sahut <i>et al.</i> , 2021; Satalkina and Steiner, 2020b, 2020a; Secundo, Rippa and Cerchione, 2020; Toniolo <i>et al.</i> , 2020; Yeganegi <i>et al.</i> , 2021)
	Teams and networking (4) Human Capital (10)	(Chae and Goh, 2020; Kollmann <i>et al.</i> , 2008; Pérez-Fernández <i>et al.</i> , 2020; Scuotto and Morellato, 2013) (Beranek and Beránek, 2015; Martinez Dy, 2022; Obschonka and Audretsch, 2020; Prendes-Espinosa <i>et al.</i> , 2021; Ratzinger <i>et al.</i> , 2018; Rayna and Striukova, 2021; Reis <i>et al.</i> , 2021; Rippa and Secundo, 2019; Sousa and Rocha, 2019; Tarabas <i>et al.</i> , 2018)

Appendix B: Questionnaire

Digital Entrepreneurship Research

Entrepreneurial Intentions in Digital Entrepreneurship

University of Macedonia, Thessaloniki, Greece



Aim of the Research

Digital Entrepreneurship* gains momentum as the most promising field of entrepreneurial activity. The study of the various factors affecting the intentions of graduate and postgraduate students to participate in such activity has increased research interest, especially under the circumstances. We would appreciate if you should offer some of your valuable time to participate in this research. The questionnaire is totally anonymous, the data are used only for statistical analysis and all responses are highly confidential. Please, feel free to contact the investigator if you need any assistance.

* The term Digital Entrepreneurship refers to the procedures for the startup and operation of a digital firm, which offers a digital product or service, or uses digital technologies in part or in whole of the business plan.

Please check the boxes below as required:

Gender *

Male	<input type="checkbox"/>
Female	<input type="checkbox"/>

Age *

18-24	<input type="checkbox"/>
25-34	<input type="checkbox"/>
35-44	<input type="checkbox"/>
45-54	<input type="checkbox"/>
55 and older	<input type="checkbox"/>

Was any one of your parents self-employed? *

No	
Yes	

Please enter your University and Dept of Studies *

Level of studies *

Graduate	
Postgraduate	

Year of studies *

1st	
2nd	
3rd	
4th	
5th or more	

Intention to start a digital business (Liñán & Chen, 2009)

Please rate the next questions : 1 - 5 (I totally disagree - I totally agree)

1	I am determined to start a digital business. *	
2	My professional goal is to become a digital entrepreneur. *	
3	I have very seriously thought of starting a digital business. *	

Education and Entrepreneurship (Souitaris *et al.*, 2007)

Please rate the next questions : 1 - 5 (I totally disagree - I totally agree)

1	My courses helped me develop original business ideas for a digital startup *	
2	My courses helped me develop the required leadership and communication skills required to get involved with digital entrepreneurship *	
3	My courses helped me develop knowledge and skills required for a digital startup *	
4	My courses offered me valuable experience from real digital business situations *	

Computer Self-Efficacy (Compeau and Higgins, 1995)

Please rate the next questions : 1 - 5 (I totally disagree - I totally agree)

1	I could complete a job using a new software package if there was no one around to tell me what to do as I go. *	
2	I could complete a job using a new software package if I had never used a package like it before *	
3	I could complete a job using a new software package if I had only the software manuals for reference. *	
4	I could complete a job using a new software package...if someone showed me how to do it first. *	

Information Technology knowledge (Zenebe *et al.*, 2018)

Please rate the next questions : 1 - 5 (I totally disagree - I totally agree)

1	I have an excellent knowledge of hardware components of computers *	
2	I have a very poor knowledge of computer operating software * (Rev)	
3	I have an excellent knowledge of database technology *	
4	I have an excellent knowledge of communication and network technologies *	
5	I have a very poor knowledge of enterprise-wide Information Systems or software * (Rev)	
6	I have an excellent knowledge of application software of computers *	
7	I have a very poor knowledge of computer programming languages * (Rev)	
8	I have an excellent knowledge of webpage development technology *	
9	My knowledge on cyber security technology is generally limited * (Rev)	

Opportunity competency (Tehseen *et al.*, 2020)

Please rate the next questions : 1 - 5 (I totally disagree - I totally agree)

1	I sought high quality business opportunities.*	
2	I take an idea or concept and make something out of it.*	
3	I scan the environment to explore opportunities.*	

Gestation entrepreneurial activities (Bosma *et al.*, 2008)

Have you recently attempted or are you currently trying starting your own digital business? *

Please check as many boxes below as required

1	Yes, I have written a business plan	
2	Yes, I have discussed a business idea with potential customers	
3	Yes, I have developed a product or service	
4	Yes, I purchased required equipment or software	
5	Yes, I have made steps to form a team	
6	Yes, I have made contacts to obtain funding	
7	Yes, I have applied for a patent or copyright	
8	Yes, I have already registered a firm	
9	No, I have not made any steps yet	

(Rev) = Reverse coded item

Appendix C: Publications

1. Sitaridis, I., & Kitsios, F. (202X). **Digital Entrepreneurship: From Intentions to Actions; the role of IT knowledge**. Small Business Economics (Under review)
2. Sitaridis, I., & Kitsios, F. (2023). **Digital entrepreneurship and entrepreneurship education: a review of the literature**. International Journal of Entrepreneurial Behaviour and Research. <https://doi.org/10.1108/IJEER-01-2023-0053> (SCOPUS, AJG2021 (3), Shimago (Q1), Impact Factor=6.4).
3. Sitaridis, I., & Kitsios, F. (2023). **Digital entrepreneurial intentions : the role of IT knowledge and Entrepreneurial program learning**. International Mobile Communications Learning, 1–11. (accepted for publication – Proceedings by Springer).
4. Laspita, S., Sitaridis I., Kitsios, F. and Sarri K. (2023) **Founder or employee? The effect of social factors and the role of entrepreneurship education**, Journal of Business Research, 155, p. 113422. doi: 10.1016/j.jbusres.2022.113422, (SCOPUS, AJG2021 (3), Shimago (Q1), Impact Factor=11.3).
5. Sitaridis I., Laspita S., Kitsios, F. and Sarri K. (2023), **Entrepreneurial Program Learning and Career Choice Intentions**, In: Matsatsinis, N., Kitsios, F., Madas, M. (Eds.), *Balkan Conference on Operational Research (BALCOR 2020) "Operational Research in the Era of Digital Transformation and Business Analytics"*, Springer Proceedings in Business and Economics.
6. Sitaridis I. and Kitsios, F. (2023), **Can Computer Self-efficacy predict Entrepreneurial Intention?**, In: Matsatsinis, N., Kitsios, F., Madas, M. (Eds.), *Balkan Conference on Operational Research (BALCOR 2020) "Operational Research in the Era of Digital Transformation and Business Analytics"*, Springer Proceedings in Business and Economics.
7. Sitaridis I., Kitsios F. (2022), **Gendered personality traits and entrepreneurial intentions: insights from Information Technology education**, Education and Training, Emerald Publishing, <https://doi.org/10.1108/ET-12-2020-0378> (Impact Factor=3.6, SCOPUS, Shimago (Q1))
8. Sitaridis, I., & Kitsios, F. (2020). "**Competitiveness analysis and evaluation of Entrepreneurial Ecosystems: a multi-criteria approach**", Annals of Operations Research, <https://doi.org/10.1007/s10479-019-03404-x> [Impact Factor (4.854), Scimago (Q1), AJG2021 (3), SCOPUS].
9. Kitsios F., Sitaridis I. and Kamariotou, M. (2021), **Entrepreneurial Education and Emotional Intelligence: A State of the Art Review**, In: Jones, P., Apostolopoulos, N., Kakouris, A., Moon, C., Ratten, V. and Walmsley, A. (Eds.), *Universities and Entrepreneurship: Meeting the Educational and Social Challenges (Contemporary Issues in Entrepreneurship Research Vol. 11)*, Emerald Publishing Limited, Bingley, Ch. 2, pp. 13-32. <https://doi.org/10.1108/S2040-724620210000011002>.

10. Sitaridis I., Kitsios F., Stefanakakis S. and Kamariotou, M. (2021), **Course Evaluation using preference disaggregation analysis: The case of an Information Communication Technology course**, In: Zilla, S. (Eds.), *Handbook of Operations Research and Management Sciences in Higher Education*, Springer Nature International'
11. Sitaridis I. and Kitsios F. (2020), "**Entrepreneurial barriers perceptions of Information Technology students**", *Proceedings of the 2020 IEEE Global Engineering Education Conference (EDUCON)*, Porto, Portugal, 27-30 April, pp. 1347-1351.
12. Sitaridis I., Laspita S., Kitsios, F. and Sarri K. (2020), "**Student Perception on Entrepreneurship Program Learning: Insights from GUESSS**", In: Kitsios, F., Matsatsinis, N., Aretoulis, G., Delias, P., Kamariotou, M., Madas, M., Papathanasiou, J., Stiakakis, E., Vergidis, K. and Ziakis, C. (Eds), *Proceedings of the XIV Balkan Conference on Operational Research (Virtual BALCOR 2020)*, Thessaloniki, Greece, 30 September – 3 October, pp. 455–459.
13. Sitaridis I. and Kitsios F. (2020), "**Computer Self-Efficacy as an Antecedent of Entrepreneurial Intention**", In: Kitsios, F., Matsatsinis, N., Aretoulis, G., Delias, P., Kamariotou, M., Madas, M., Papathanasiou, J., Stiakakis, E., Vergidis, K. and Ziakis, C. (Eds), *Proceedings of the XIV Balkan Conference on Operational Research (Virtual BALCOR 2020)*, Thessaloniki, Greece, 30 September – 3 October, pp. 460-464.
14. Laspita S., Sitaridis I., Kitsios, F. and Sarri K. (2020), "**Entrepreneurship program learning: Different views of latent, nascent, active entrepreneurs and abstainers**", *Proceedings of the European Conference on Innovation and Entrepreneurship (ECIE20)*, Rome, Italy, 2020-September, pp. 352–359.
15. Sitaridis, I., & Kitsios, F. (2018). "**Entrepreneurship as a career option for Information Technology students: critical barriers and the role of motivation**", *Journal of the Knowledge Economy*, 10(3), 1133-1167, <https://doi.org/10.1007/s13132-018-0519-z> [Impact Factor (3.3), Scimago (Q2), SCOPUS].
16. Sitaridis, I., & Kitsios, F. (2017). "**Entrepreneurial Intentions of Information Technology students: the Theory of Planned Behavior, the role of Gender and Education**", *J. for International Business and Entrepreneurship Development*, 10(3), 316–335. [Scimago (Q3), SCOPUS]

Appendix D. List of articles in the LR

Authors	Title	Journal	Year	Type of Research	Keywords	Conceptual dimension / Sub-stream						
						LR previous	ICT Dominance	Learning Approaches	Digital Learning	Success Factors	Behavioural	Ecosystem
1 Allen	On the Cutting Edge or the Chopping Block? Fostering a Digital Mindset and Tech Literacy in Business Management Education	JOURNAL OF MANAGEMENT EDUCATION	2020	Conceptual paper	tech literacy; digital mindset; future of work; management education; management business education; technology enabled disruption; innovation	9	16	16	11	6	19	23
2 Alzamel S., Nazri M., Omar S.	Factors influencing e-entrepreneurial intention among female students in Saudi Arabia	International Journal of Criminology and Sociology	2020	Quantitative	Perceived Social Support; Theory of Planned Behavior; Attitude Towards Entrepreneurial; Subjective Norms; Entrepreneurial Self-Efficacy; E-Entrepreneurship Intention; Saudi Arabia.						*	
3 Androutsos, A; Brinia, V	Developing and Piloting a Pedagogy for Teaching Innovation, Collaboration, and Co-Creation in Secondary Education Based on Design Thinking, Digital Transformation, and Entrepreneurship	EDUCATION SCIENCES	2019	Quantitative	design thinking; pedagogy; innovation; collaboration; co-creation; education; digital skills; entrepreneurship			*				
4 Ashraf M.A., Alam M.M.D., Alexa L.	Making decision with an alternative mindset: Predicting entrepreneurial intention toward f-commerce in a cross-country context	Journal of Retailing and Consumer Services	2021	Quantitative	Attitude; Perceived behavioral control; Reliability; Self-efficacy; f-commerce; entrepreneurial intention; Bounded rationality						*	
5 Batool H., Rasheed H., Malik M.I., Hussain S.	Application of partial least square in predicting e-entrepreneurial intention among business students: evidence from Pakistan	Journal of Innovation and Entrepreneurship	2015	Quantitative	Business students; Self-efficacy; Online business; Intention; EAO						*	
6 Beranek L.	The attitude of the college students to entrepreneurial skills development in the subject E-commerce	Informatics in Education	2015	Qualitative	entrepreneurship; electronic commerce; education; active learning							*

7	Birch, C; Lichy, J; Mulholland, G; Kachour, M	An enquiry into potential graduate entrepreneurship Is higher education turning off the pipeline of graduate entrepreneurs?	JOURNAL OF MANAGEMENT DEVELOPMENT	2017	Mixed methods	Employability; Entrepreneurship; Pedagogy; Educational innovation; Management strategy		*
8	Carenys, J; Moya, S	Digital game-based learning in accounting and business education	ACCOUNTING EDUCATION	2016	Literature review	Digital game-based learning; videogames; simulations; accounting education; serious games		*
9	Carrier, C, Raymond, L, & Eltaief, A.	Cyberentrepreneur: a multiple case study	International Journal of Entrepreneurial Behaviour & Research	2004	Case study	Entrepreneurs; Internet; Small enterprises		*
10	Chae B.K., Goh G.	Digital entrepreneurs in artificial intelligence and data analytics: Who are they?	Journal of Open Innovation: Technology, Market, and Complexity	2020	Quantitative	digital entrepreneurs; personality traits; digital data; machine learning; open innovation		* *
11	Chang S.-H., Wang C.-L., Lee J.-C., Yu L.-C.	Who needs entrepreneurial role models? Driving forces of students' cyber-entrepreneurial career intention	Eurasia Journal of Mathematics, Science and Technology Education	2018	Quantitative	career decisions; cyber entrepreneurial intentions; cyber entrepreneurial self-efficacy; entrepreneurship education; goal commitment		*
12	Chang, JC; Hsiao, YD; Chen, SC; Yu, TT	Core entrepreneurial competencies of students in departments of electrical engineering and computer sciences (EECS) in universities	EDUCATION AND TRAINING	2018	Quantitative	College students; Practicum; Entrepreneurial competency; University of technology		*
13	Chang, SH; Shu, Y; Wang, CL; Chen, MY; Ho, WS	Cyber-entrepreneurship as an innovative orientation: Does positive thinking moderate the relationship between cyber-entrepreneurial self-efficacy and cyber-entrepreneurial intentions in Non-IT students?	COMPUTERS IN HUMAN BEHAVIOR	2020	Quantitative	Cyber-entrepreneurial self-efficacy; Cyber-entrepreneurial intentions; Positive thinking; Cultivating innovation		*
14	Chen L.	IT entrepreneurial intention among college students: An empirical study	Journal of Information Systems Education	2013	Quantitative	Entrepreneurship; Computer self-efficacy; Behavioral modeling; Social impact theory		*
15	Chen L.	Understanding IT entrepreneurial intention: An information systems view	Journal of Computer Information Systems	2014	Quantitative	IT entrepreneurial intention; Personal innovativeness in IT (PIIT); Computer self-efficacy (CSE); Entrepreneurial self-efficacy (CSE); Risk propensity		*

16	Cirulli, F; Elia, G; Lorenzo, G; Margherita, A; Solazzo, G	The use of MOOCs to support personalized learning: An application in the technology entrepreneurship field	KNOWLEDGE MANAGEMENT & E-LEARNING-AN INTERNATIONAL JOURNAL	2016	Qualitative	Competence development; Curriculum development; Entrepreneurship education; MOOC; Open learning; Personalization; Technology entrepreneurship	*
17	Clarke, T; Clarke, E	Born digital? Pedagogy and computer-assisted learning	EDUCATION AND TRAINING	2009	Conceptual paper	Communication technologies; Education; Computer based learning; Knowledge economy	*
18	Del Giudice, Manlio, and Detmar Straub. 2011.	IT and Entrepreneurism: An On-Again Love Affair or a Marriage.	MIS Quarterly	2011	Editorial		*
19	Dhar, V; Sundararajan, A	Information technologies in business: A blueprint for education and research	INFORMATION SYSTEMS RESEARCH	2007	Qualitative	IT strategy; corporate strategy; IT investment; education; electronic commerce; business transformation; disruptive technology; platform; business value; decision making; digital goods; network economics; social networks; MBA core	*
20	Elia, G., Margherita, A., Passiante, G.	Digital entrepreneurship ecosystem: how digital technologies and collective intelligence are reshaping the entrepreneurial process	Technological Forecasting and Social Change	2020	Conceptual paper	Collective intelligence; Digital entrepreneurship; Digital technologies; Entrepreneurial process; Ecosystem; Framework	*
21	Yaghoubi Farani, AY; Karimi, S; Motaghd, M	The role of entrepreneurial knowledge as a competence in shaping Iranian students' career intentions to start a new digital business	EUROPEAN JOURNAL OF TRAINING AND DEVELOPMENT	2017	Quantitative	Theory of planned behaviour; Entrepreneurship; Competence; Digital entrepreneurship; Entrepreneurial career intentions; Entrepreneurial knowledge	*
22	Ferreras-Garcia, R; Hernandez-Lara, AB; Serradell-Lopez, E	Entrepreneurial competences in a higher education business plan course	EDUCATION AND TRAINING	2019	Quantitative	Competences; Higher education; Entrepreneurship; Online education; Business plan	*
23	Galanakis, K; Giourka, P	Entrepreneurial path: decoupling the complexity of entrepreneurial process	INTERNATIONAL JOURNAL OF ENTREPRENEURIAL BEHAVIOR & RESEARCH	2017	Qualitative	Self-efficacy; Systems thinking; Entrepreneurial intentions; Social capital; Entrepreneurial context; Network ties	*
24	Ghatak A., Chatterjee S., Bhowmick B.	Intention Towards Digital Social Entrepreneurship: An Integrated Model	Journal of Social Entrepreneurship	2020	Quantitative	Digital; social entrepreneurship; feasibility; desirability; self-efficacy	*

25	Giuggioli, Pellegrini	Artificial intelligence as an enabler for entrepreneurs: a systematic literature review and an agenda for future research	INTERNATIONAL JOURNAL OF ENTREPRENEURIAL BEHAVIOR & RESEARCH	2022	Literature review	Entrepreneurship; Artificial intelligence; Machine learning; Deep learning; Innovation; Technology	*	
26	Huebscher, J., & Lendner, C.	Effects of entrepreneurship simulation game seminars on entrepreneurs' and students' learning.	Journal of Small Business and Entrepreneurship	2010	Quantitative			*
27	Jones, N; Lau, AMS	Blending learning: widening participation in higher education	HUMAN FACTORS AND ERGONOMICS IN MANUFACTURING & SERVICE INDUSTRIES	2010	Qualitative	blended learning; widening participation; social inclusion		*
28	Kang, Y; Lee, K	Designing technology entrepreneurship education using computational thinking	EDUCATION AND INFORMATION TECHNOLOGIES	2020	Mixed methods	Computational thinking; Project-based learning; Non-engineering students; Social innovation; Entrepreneurship	*	
29	Kollmann T,Hasel M,Breugst N	Competence of IT professionals in e-business venture teams: the effect of experience and expertise on preference structure	Journal of Management Information Systems	2009	Quantitative	competence of IT professionals; competence profile; competence valuation; conjoint analysis; e-business; team composition		*
30	Kollmann T.	Eras of Digital Entrepreneurship	Business & Information Systems Engineering	2021	Literature Review	Digital entrepreneurship terminology; Scoping literature review; Historical eras; Cross-mentions	* _	*
31	Kraus, S; Palmer, C; Kailer, N; Kallinger, FL; Spitzer, J	Digital entrepreneurship A research agenda on new business models for the twenty-first century	INTERNATIONAL JOURNAL OF ENTREPRENEURIAL BEHAVIOR & RESEARCH	2018	Literature review	Business development; Opportunity; Entrepreneurship	* _	*
32	Ladeira M.J.M., Ferreira F.A.F., Ferreira J.J.M., Fang W., Falcão P.F., Rosa Á.A.	Exploring the determinants of digital entrepreneurship using fuzzy cognitive maps	International Entrepreneurship and Management Journal	2019	Qualitative	Cause-and-effect relationships ; Digital entrepreneurship ; Entrepreneurship; Fuzzy cognitivemap (FCM) ; Technology		*
33	Lamine, W; Mian, S; Fayolle, A; Linton, JD	Educating scientists and engineers for technology entrepreneurship in the emerging digital era	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	2021	Call for papers	Entrepreneurship education; Science and Technology Entrepreneurship; Digitalization	*	

34	Laptev, G; Shaytan, D	Co-design-based learning for entrepreneurs in the digital age	MEASURING BUSINESS EXCELLENCE	2021	Quantitative	Entrepreneurship; Digital; Design thinking; Fuzzy front end; Co-design-based learning; Innovative thinking	*
35	Le Dinh T., Vu M.C., Ayayi A.	Towards a living lab for promoting the digital entrepreneurship process	International Journal of Entrepreneurship	2018	Conceptual paper	Living Lab; Digital Entrepreneurship; Start-up; Business Development; Action Design Research	*
36	Linzone, R; Schiuma, G; Ammirato, S	Connecting universities with entrepreneurship through digital learning platform: functional requirements and education-based knowledge exchange activities	INTERNATIONAL JOURNAL OF ENTREPRENEURIAL BEHAVIOR & RESEARCH	2020	Case study	Academic entrepreneurship; Digital academic entrepreneurship; Digital learning platform; MOOCs functions; Enterprise university	*
37	Mancha R., Shankaranarayanan G.	Making a digital innovator: antecedents of innovativeness with digital technologies	Information Technology and People	2020	Quantitative	Digital innovation; Entrepreneurial orientation; Self-efficacy; Digital literacy; Experiential learning	*
38	Mand H.S., Atri M., Gill A.	Influence of unemployment and education on women's intentions to start e-entrepreneurship: Evidence from Indian survey data	International Journal of Entrepreneurship and Small Business	2018	Quantitative	e-entrepreneurship; unemployment; education; family size; India	*
39	Martinez Dy A.	Levelling the playing field? Towards a critical-social perspective on digital entrepreneurship	Futures	2019	Conceptual paper	Digital Enterprise; Entrepreneurship; Cyberfeminism; Intersectionality; Social embeddedness	*
40	Matlay, H.	E-entrepreneurship and small e-business development: towards a comparative research agenda	Journal of Small Business and Enterprise Development	2004	Conceptual paper	Internet; Electronic commerce; Small to medium-sized enterprises; Research	*
41	Millman C., Li Z., Matlay H., Wong W.	Entrepreneurship education and students' internet entrepreneurship intentions: Evidence from Chinese HEIs	Journal of Small Business and Enterprise Development	2010	Quantitative	Entrepreneurialism; Education; Internet; Motivation (psychology); China	*
42	Millman, C; Wong, WC; Li, ZW; Matlay, H	Educating students for e-entrepreneurship in the UK, the USA and China	INDUSTRY AND HIGHER EDUCATION	2009	Mixed methods	entrepreneurship education; e-entrepreneurship; comparative research; UK; USA; China	*
43	Monllor, J; Soto-Simeone, A	The impact that exposure to digital fabrication technology has on student entrepreneurial intentions	INTERNATIONAL JOURNAL OF ENTREPRENEURIAL BEHAVIOR & RESEARCH	2020	Quantitative	Technology; Entrepreneurial intention; Entrepreneurship; Entrepreneurial education	*

44	Morris, TH; Konig, PD	Self-directed experiential learning to meet ever-changing entrepreneurship demands	EDUCATION AND TRAINING	2021	Literature review	Self-directed learning (SDL); Kolb's experiential learning cycle; Adaptivity; Meta-competence; Entrepreneurial orientation; Digital age	*
45	Muafi, Syafri, Orabowo, Nur	Digital Entrepreneurship in Indonesia: A Human Capital Perspective	Journal of Asian Finance, Economics and Business	2021	Qualitative	Digital Entrepreneurship; Academic Entrepreneurship; Human Capital	*
46	Nambisan, S.	Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship.	entrepreneurship Theory and Practice	2016	Literature Review		* *
47	Nzembayie K.F., Buckley A.P., Cooney T.	Researching Pure Digital Entrepreneurship – A Multimethod Insider Action Research approach	Journal of Business Venturing Insights	2019	Conceptual paper	Digital entrepreneurship; Multimethod; Insider Action Research; Design research	*
48	Obschonka M, Audretsch DB	Artificial intelligence and big data in entrepreneurship: a new era has begun.	Small Business Economics	2020	Editorial	Entrepreneurship; Artificial intelligence; AI; Big data; Machine learning; Smart entrepreneurship	*
49	Pereira C.S., Durão N., Fonseca D., Ferreira M.J., Moreira F.	An educational approach for present and future of digital transformation in portuguese organizations	Applied Sciences (Switzerland)	2020	Quantitative	digital transformation; agility; PBL; innovation accelerators; technology; business processes and learning	*
50	Perez-Fernandez, H; Martin-Cruz, N; Delgado-Garcia, JB; Rodriguez-Escudero, AI	Online and Face-to-Face Social Networks and Dispositional Affectivity. How to Promote Entrepreneurial Intention in Higher Education Environments to Achieve Disruptive Innovations?	FRONTIERS IN PSYCHOLOGY	2020	Quantitative	disruptive innovation; entrepreneurial intention; social networks; dispositional affectivity; digital transformation	*
51	Prendes-Espinosa P., Solano-Fernández I.M., García-Tudela P.A.	Emdigital to promote digital entrepreneurship: The relation with open innovation	Journal of Open Innovation: Technology, Market, and Complexity	2021	Qualitative	digital entrepreneurship; competences model; higher education; EntreComp; DigComp;	*
52	Ratten, V	Coronavirus (Covid-19) and the entrepreneurship education community	JOURNAL OF ENTERPRISING COMMUNITIES- PEOPLE AND PLACES IN THE GLOBAL ECONOMY	2020	Conceptual paper	Community; Coronavirus; Covid-19; Education; entrepreneurship education; Learning; Management; Community of practice	*
53	Ratten, V; Usmanij, P	Entrepreneurship education: Time for a change in research direction?	INTERNATIONAL JOURNAL OF MANAGEMENT	2021	Conceptual paper	Education; Entrepreneurship education; Gig economy; Future trends	*

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54	Ratzinger, D; Amess, K; Greenman, A; Mosey, S	The impact of digital start-up founders' higher education on reaching equity investment milestones	JOURNAL OF TECHNOLOGY TRANSFER	2018	Quantitative	University qualifications; Human capital; Equity investments; Digital economy	*
55	Rayna, T; Striukova, L	Fostering skills for the 21st century: The role of Fab labs and makerspaces	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	2021	Qualitative	Entrepreneurship; Technology education; 21st Century Skills; Fab labs; Makerspaces; 3D printing	* *
56	Reis, DA; Fleury, AL; Carvalho, MM	Consolidating core entrepreneurial competences: toward a meta-competence framework	INTERNATIONAL JOURNAL OF ENTREPRENEURIAL BEHAVIOR & RESEARCH	2021	Literature Review	Entrepreneurs; Entrepreneurship; Entrepreneurship education	* *
57	Rippa P., Secundo G.	Digital academic entrepreneurship: The potential of digital technologies on academic entrepreneurship	Technological Forecasting and Social Change	2019	Literature review	Academic entrepreneurship; Digital academic entrepreneurship; Digital technologies; Entrepreneurial university	* - *
58	Rof A., Bikfalvi A., Marquès P.	Digital transformation for business model innovation in higher education: Overcoming the tensions	Sustainability (Switzerland)	2020	Mixed methods	business model; business model innovation; digital transformation; university; higher education institution; tensions	*
59	Rohm	Future Proof and Real-World Ready: The Role of Live Project-Based Learning in Students' Skill Development	Journal of Marketing Education	2021	Qualitative	digital marketing; live project-based learning; client-based projects; meta-skills; 4Cs; creativity; critical thinking; collaboration; communication; technical skills	*
60	Sahut J.-M., landoli L., Teulon F.	The age of digital entrepreneurship	Small Business Economics	2021	Literature Review -SI	Digital entrepreneurship; Information; Ecosystem. Start-ups; Business model; Platform	*
61	Satalkina, L. and Steiner, G.	Digital entrepreneurship and its role in innovation systems: a systematic literature review as a basis for future research avenues for sustainable transitions	Sustainability (Switzerland)	2020	Literature Review	digital entrepreneurship; innovation system; PRISMA; digital transformation; sustainable transition	* *

62	Satalkina, L. and Steiner, G.	Digital Entrepreneurship: A Theory-Based Systematization of Core Performance Indicators	Sustainability (Switzerland)	2020	Quantitative	digital entrepreneurship; digital transformation; integrated performance indicators; sustainable transformation and transition capacity; innovation system resilience; complex societal transitions		*
63	Scuotto, V; Morellato, M	Entrepreneurial Knowledge and Digital Competence: Keys for a Success of Student Entrepreneurship	JOURNAL OF THE KNOWLEDGE ECONOMY	2013	Quantitative	Student entrepreneurship . Building collaborative networks . Knowledge . Digital competence		*
64	Secundo G., Rippa P., Cerchione R.	Digital Academic Entrepreneurship: A structured literature review and avenue for a research agenda	Technological Forecasting and Social Change	2020	Literature review	Academic entrepreneurship; Bibliometric analysis; Digital technologies; Digital academic entrepreneurship; Digital transformation; Literature review; Software R; VOSviewer	*	*
65	Secundo, G; Mele, G; Del Vecchio, P; Elia, G; Margherita, A; Ndou, V	Threat or opportunity? A case study of digital-enabled redesign of entrepreneurship education in the COVID-19 emergency	TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	2021	Case study	Contamination Lab; Covid-19; Digital technologies; Entrepreneurship education; Entrepreneurial learning; Entrepreneurial Mindset; Virtual elevator pitch	*	
66	Secundo, G; Rippa, P; Meoli, M	Digital transformation in entrepreneurship education centres: preliminary evidence from the Italian Contamination Labs network	INTERNATIONAL JOURNAL OF ENTREPRENEURIAL BEHAVIOR & RESEARCH	2020	Quantitative	Academic entrepreneurship; Contamination labs; Digital technologies; Digital transformation; Entrepreneurship centres; Entrepreneurship education	*	
67	Shawn P. Daly	Student-Operated Internet Businesses: True Experiential Learning in Entrepreneurship and Retail Management	Journal of Marketing Education	2001	Mixed methods		*	
68	Shimoli S.M., Cai W., Abbas Naqvi M.H., Lang Q.	Entrepreneurship success traits. Do Kenyans possess the desired entrepreneur personality traits for enhanced E-entrepreneurship? Case study of Kenyan students in the people's republic of China	Cogent Business and Management	2020	Quantitative	E-entrepreneurship; personality traits; entrepreneur success; big-5; self- efficacy; locus of control; need for achievement		*
69	Shurville, S; Rospigliosi, A	Implementing blended self-managed action learning for digital entrepreneurs in higher education	ACTION LEARNING	2009	Qualitative	blended self-managed action learning; entrepreneurs; higher education; self-managed action learning	*	

70	Siriattakul P., Jermstittiparsert K.	Exploring the nexus between entrepreneurial skills, environmental support, motivational factors and entrepreneur intention among the Thai University Graduates	International Journal of Innovation, Creativity and Change	2019	Quantitative	Entrepreneurial Skill; Environmental Support; Motivational Factors and Entrepreneur Intention; Thai university graduates.	*
71	Sousa, MJ; Rocha, A	Skills for disruptive digital business	Journal of Business Research	2019	Mixed methods	Managers; Skills; Competitiveness; IT; Disruptive business	*
72	Stefan Vorbach, Elisabeth Maria Poandl, Ines Korajman	Digital Entrepreneurship Education The Role of MOOCs	International Journal of Engineering Pedagogy	2019	Quantitative	Digital entrepreneurship; digital entrepreneurship education; massive open online course; mooc	*
73	Steininger, D.M.	Linking information systems and entrepreneurship: A review and agenda for IT-associated and digital entrepreneurship research.	INFORMATION SYSTEMS JOURNAL	2019	Literature Review	business model; digital entrepreneurship; entrepreneurship; information technology; review; start-up	* *
74	Sun, XM	Exploration and Practice of Internet plus Maker Education University Innovative Entrepreneurship Education Model From the Perspective of Positive Psychology	FRONTIERS IN PSYCHOLOGY	2020	Quantitative	positive psychology; the internet; maker education; innovative entrepreneurship; education model	*
75	Tarabasz, A; Selakovic, M; Abraham, C	The Classroom of the Future: Disrupting the Concept of Contemporary Business Education	ENTREPRENEURIAL BUSINESS AND ECONOMICS REVIEW	2018	Conceptual paper	classroom of the Future; business education; economic education	*
76	Thanachawengsakul	The Development of a MOOCs Knowledge Repository System Using a Digital Knowledge Engineering Process to Enhance Digital Entrepreneurs' Competencies	International Journal of Engineering Pedagogy	2021	Quantitative	MOOCs; knowledge repository system; digital knowledge engineering process; digital entrepreneurs' competencies	*
77	Toniolo K., Masiero E., Massaro M., Bagnoli C.	A grounded theory study for digital academic entrepreneurship	INTERNATIONAL JOURNAL OF ENTREPRENEURIAL BEHAVIOR & RESEARCH	2019	Conceptual paper	Digital academic entrepreneurship; Academic spin-off; University; Grounded theory; Ca' Foscari University of Venice; Strategy Innovation	*
78	van der Westhuizen T., Goyayi M.J.	The influence of technology on entrepreneurial self-efficacy development for online business start-up in developing nations	International Journal of Entrepreneurship and Innovation	2020	Quantitative	business tech start-up; entrepreneurial self-efficacy; entrepreneurship action learning; online business start-up; online entrepreneurship and innovation in	*

							developing nations
79	Wang Y.-S., Tseng T.H., Wang Y.-M., Chu C.-W.	Development and validation of an internet entrepreneurial self-efficacy scale	Internet Research	2019	Quantitative	Measurement; Scale development; Internet entrepreneurial intention; Internet entrepreneurial self-efficacy; Internet entrepreneurship	*
80	Wang, YM; Chiou, CC	Factors Influencing the Willingness of Universities' Business Management Departments to Implement Online Entrepreneurship Program and Its Effectiveness	FRONTIERS IN PSYCHOLOGY	2020	Quantitative	online entrepreneurship; online entrepreneurship program; the effectiveness of online; entrepreneurship program; willingness to implement online entrepreneurship program; universities' business; management departments	*
81	Wang, YS; Lin, SJ; Yeh, CH; Li, CR; Li, HT	What drives students' cyber entrepreneurial intention: The moderating role of disciplinary difference	THINKING SKILLS AND CREATIVITY	2016	Quantitative	Cyber entrepreneurial intention; Personality traits; Intrinsic motivation; Extrinsic motivation	*
82	Yeganegi, S., Laplume, A. O., & Dass, P.	The role of information availability: A longitudinal analysis of technology entrepreneurship	Technological Forecasting and Social Change	2021	Quantitative	Technology entrepreneurship; Information availability; Intellectual property rights; Cross-country analysis	*
83	Yeh, CH; Wang, YS; Hsu, JW; Lin, SJ	Predicting individuals' digital autopreneurship: Does educational intervention matter?	Journal of Business Research	2020	Quantitative	Digital autopreneurship; Entrepreneurial intention; Big Five personality traits; Intrinsic motivation; Extrinsic motivation; Educational interventions; entrepreneurial intention; big five personality; intrinsic motivation; educational interventions	*
84	Youssef B., Boubaker A., Dedaj S., Carabregu-Vokshi M.	Digitalization of the economy and entrepreneurship intention	Technological Forecasting and Social Change	2021	Quantitative	Entrepreneurship; Entrepreneurial intention; Digitalization; Kosovo	*
85	Zaheer H., Breyer Y., Dumay J.	Digital entrepreneurship: An interdisciplinary structured literature review and research agenda	Technological Forecasting and Social Change	2019	Literature review	Digital entrepreneurship; Digital start-up; Internet venture; Digital venturing; Online start-ups	* *
86	Zaheer H., Breyer Y., Dumay J., Enjeti M.	Straight from the horse's mouth: Founders' perspectives on achieving 'traction' in digital start-ups	COMPUTERS IN HUMAN BEHAVIOR	2019	Case study	Digital entrepreneurship; Digital start-ups; Internet start-ups; Entrepreneurial performance	*
87	Zenebe A., Alsaaty F.M., Anyiwo D.	Relationship between individual's entrepreneurship intention, and adoption and knowledge of information technology	Journal of Small Business and Entrepreneurship	2018	Qualitative	information technology knowledge; Information technology adoption; Entrepreneurial intention; General	*

and its applications: an empirical study			measure of enterprising tendency (GET2) test				
88	Zhang, S	Successful Internet Entrepreneurs Don't Have To Be College Dropouts: A Model for Nurturing College Students to Become Successful Internet Entrepreneurs	INTERNATIONAL JOURNAL OF INFORMATION AND COMMUNICATION TECHNOLOGY EDUCATION	2014	Quantitative	Business Education; Entrepreneurship; Entrepreneurship Education; Internet Entrepreneurship; Internet Startup; Technology Education	*
89	Zur, A	Two Heads Are Better Than One- Entrepreneurial Continuous Learning through Massive Open Online Courses	EDUCATION SCIENCES	2020	Mixed methods	entrepreneurial education; continuous learning; digital learning; online learning; MOOCs	*

Table 11. List of articles in the LR