International Journal of Education Economics and Development

ISSN online: 1759-5681 - ISSN print: 1759-5673
https://www.inderscience.com/ijeed

Digital technologies adopted by universities to support entrepreneurial students' spin-offs

Ronnie Figueiredo, Alvaro Lopes Dias, Maria José Sousa

DOI: 10.1504/IJEED.2023.10051770

Article History:
Received: 28 February 2022
Accepted: 05 September 2022
Published online: 22 January 2024

Digital technologies adopted by universities to support entrepreneurial students' spin-offs

Ronnie Figueiredo

Centre of Applied Research in Management and Economics (CARME),
School of Technology and Management (ESTG),
Polytechnic of Leiria,
Campus 2, Morro do Lena, Alto Vieiro, Leiria, Portugal
and
Research Center in Business Sciences,
NECE (UBI), Estrada do Sineiro, s/n, Covilhã, Portugal
and
Spinner Innovation Centre (SIC),
Quinta da Trindade s/n, Setúbal, Portugal
Email: research@spinnercentre.com

Alvaro Lopes Dias

TRIE/ECEO,
Universidade Lusófona,
Campo Grande 376, 1749-024 Lisboa, Portugal
and
ISCTE Instituto Universitário de Lisboa,
Avenida das Forças Armadas, 1649-026 Lisboa, Portugal
Email: alvaro.dias1@gmail.com

Maria José Sousa*

ISCTE Instituto Universitário de Lisboa,
Avenida das Forças Armadas, 1649-026 Lisboa, Portugal
Email: maria.jose.sousa@iscte.iul.pt
*Corresponding author

Abstract: This paper presents a theoretical approach based on the systematic literature review (SLR) method. The objective of the study was identifying the digital technologies adopted by universities to support entrepreneurial students' spin-offs. We identified 98 studies in the first round of Scopus database, in the period from 2004 to 2022, and conclude the analysis with 42 papers, after others rounds. Data collection was performed through the Boolean technique, using the keywords 'digital innovation' and 'university'. The results point to several technologies, in special MOOCs and mobiles application. The study contributes significantly to future research in the field of entrepreneurial universities, which encourage the generation of digital businesses, from the development of spin offs working to the entrepreneurial students.

Keywords: innovation; spin offs; entrepreneurship; university; management; digital; systematic literature review; SLR.

Reference to this paper should be made as follows: Figueiredo, R., Dias, A.L. and Sousa, M.J. (2024) 'Digital technologies adopted by universities to support entrepreneurial students' spin-offs', *Int. J. Education Economics and Development*, Vol. 15, Nos. 1/2, pp.195–219.

Biographical notes: Ronnie Figueiredo is a scientist in Innovation and Emerging Technologies at Centre of Applied Research in Management and Economics (CARME), Polytechnic of Leiria. He preferred peer reviewer for the economics of innovation portfolio to Routledge Taylor & Francis Group. He is an Associate Editor of Innovation and Management Review (INMR), Emerald/Scopus. He is the Chairman of Spinner Innovation Centre, and author of Spinner Innovation Model®. His research methods are data mining and geographic information science (GIS).

Alvaro Lopes Dias is a Full Professor of Strategy and Entrepreneurship at Universidade Lusófona/TRIE and ISCTE-IUL, Lisbon, Portugal. He holds two PhDs one in Management and Marketing and another in Tourism, Postdoctoral studies in Management, MSc in Strategy, and MBA in International Business. He has over 26 years of teaching experience. He has had several visiting positions in different countries and institutions including Brazil, Angola, Spain, Saudi Arabia, Poland, and Finland. He has produced extensive research in the field of *Tourism and Management*. His work has published *Current Issues in Tourism*, *Journal Sustainable Tourism*, *Journal Brand Management* or *Business Process Management Journal*.

Maria José Sousa is a University Professor and Research Fellow at ISCTE/IUL and of CIEO (Algarve University). Her research interests currently are public policies and political science, innovation and business management issues. She is a best seller author in ICT and people management and has co-authored over 70 articles and book chapters and published in several scientific journals (e.g., *Journal of Business Research*, *UAIS*, *Future Generations Computer Systems*, *Journal of Medical Systems*, *International Journal of Knowledge, Culture and Change Management*, *Knowledge Management*, *WSEAS Transactions on Business and Economics*, *Information Systems Frontiers and* others), she has organised and peer-reviewed international conferences. She is also External Expert of COST Association – European Cooperation in Science and Technology.

1 Introduction

University spin-offs emerge from the transfer of knowledge and technologies from the university to the new business and the team of managers and founders of the business are members of the university, namely, students and professors or researchers. Nowadays, most part of the universities creates infrastructures to support the students in their entrepreneurship endeavours.

The educational process in the university allows the transfer of knowledge between the professors and researchers and the students, creating a background for the building of new businesses (Wright et al., 2006). And the universities have specific infrastructures that support the students to develop their own ideas and create the conditions to make

them growth – in terms of physical space and other material resources, knowledge, and technologies.

Public policies and research funding programmes are the base of the financial structure of the entrepreneurship endeavours of the students, professors, and researchers. All types of entrepreneurial business can emerge from the university context (Walter et al., 2006), but mostly the technological entrepreneurship is a winner, and the university spin-off can occur based on intellectual property registration as a patent or via technology licensing (Di Gregorio and Shane, 2003).

The university spin-off is a thematic studied from different fields of research and educational entrepreneurship has also gained more interest and visibility in the past 10 years, mainly because of the market failure (Berbegal-Mirabent et al., 2015), and as a response to creation of jobs among students that are finishing their courses and have difficulties in entering the labour market (McAdam and McAdam, 2008).

In recent years, researchers have been developing studies on the 'university spin-offs' applying different research methods like 'propensity-score matching' (Son et al., 2022); 'case study' (Almeida, 2021); 'regression model' (Fernández-López et al., 2022) and 'event analysis techniques' (Rodeiro-Pazos et al., 2022).

Existing work focuses on very specific parts of university spin-offs but suffers from a lack of overview of the main research attributes regarding technology in the past years, a gap this study intended to cover.

Some examples of this specific approach were presented by Nikou and Aavakare (2021) that developed a model to examine the impact of information and digital literacy. In addition, Selwyn et al. (2011) studied the mainstream adoption of different online proctoring systems. Moreover, González et al. (2022), explore students' digital technology approaches to learning. On top of that, Mikheev et al. (2021) analyse the current trends in the digital transformation of educational institutions. In terms of review study, Rapanta et al. (2021) worked a literature review considering the papers published in one year.

The main goal of this research is to identify the digital technologies adopted by universities to support entrepreneurial students' spin-offs. To support the study, we proposed a main question (problem): *What are the digital technologies adopted by universities to support entrepreneurial students' spin-offs?* For this purpose, a systematic literature review (SLR) was accomplished, making a diagnosis, and giving directions to students in spin-off university contexts.

2 Background

2.1 University spin-offs

Academic spin-offs are recognised for their effectiveness in transferring scientific knowledge to industry (Rasmussen and Wright, 2015) and for their importance as a catalyst of the innovation system in many countries (Sousa-Ginel et al., 2021). Although the definition of university spin-off is not consensual (Soetanto and Van Geenhuizen, 2015), there is a recognition that founders can be varied: students, recent graduates or academic staff (Soetanto and Jack, 2016). In this context, Carayannis et al. (1998) describe a university spin-off as a company created by one such member of the

university, who either left the university to create that company or who started the venture while still affiliated with it.

However, this definition does not make explicit the role of the university in the development of knowledge and research, an essential factor of the concept and one that meets with broad academic consensus (Clarysse et al., 2014). Thus, more recent research defines a university spin-off as an independent company aiming to convert knowledge and research developed at the university into marketable products, processes and services (Pirnay et al., 2003).

To clearly establish the distinction to other spin-offs, Soetanto and Jack (2016) list the following characteristics that a spin-off must meet:

1 the founders come from a university

2 the business of the company is associated products, processes, or services generated in the university context

3 the transfer of knowledge or research to the company must be direct and not resulting from through hiring university personnel.

Thus, university spin-offs can be distinguished from other counterparts by direct access to knowledge and research generated in academia, raising their potential for regular generation of innovation (Nosella and Grimaldi, 2009). Another important distinction relates to their contribution to the knowledge economy and their ability to generate disruptive innovation (Rodríguez-Gulías et al., 2016).

This 'common origin' of university and spin-off referred to by Soetanto and Van Geenhuizen (2015) often originates within a relationship that is both informal and trusting (Johansson et al., 2005). While the advantages are evident, this relationship may also be one of dependence due, on the one hand, to that same trust relationship, which may prevent the participation of other players and, on the other hand, to dependence on the knowledge source (Treibich et al., 2013). Despite this possible limitation, studies show that university spin-offs generally have a higher innovation capacity when compared to other non-academic spin-offs (Lejpras, 2014). Indeed, their development in an academic context has a significant effect regarding knowledge transfer and innovation generation (Corsi and Prencipe, 2016).

According to Soetanto and Jack (2016), university spin-offs, by integrating highly specialised researchers in a particular technology, face the barrier of market access. This problem may be overcome through the regularity of the innovation generated, the development of products and services and the implementation of innovative business models (Soetanto and Jack, 2016). Corsi and Prencipe (2016) recognise that there are several methods that can be used by universities for knowledge transfer and innovation. The effectiveness of university spin-off processes (Vinig and Van Rijsbergen, 2010) is related to different combinations of solutions for accessing financial resources, human capital, and other organisational and technological resources available at the university (Rodeiro-Pazos et al., 2012; Rasmussen et al., 2015).

One of the models consists of technology transfer offices (TTO) which support technology diffusion by licensing to industry the industrial or intellectual property generated in academia (Algieri et al., 2013). Their role is termed complementary (Corsi and Prencipe, 2016) with particular emphasis on defending research results and improving innovative activities in university spin-offs (O'shea et al., 2005).

Another model consists of the university science park (Minguillo et al., 2015). These parks are identified in the literature as infrastructures that stimulate and control the transfer of knowledge and technology between universities and the development of innovation-based university spin-offs (Corsi and Prencipe, 2016). Their comparative importance to other models results from their potential to stimulate the exchange of technology and knowledge between companies and spin-offs (Montoro-Sánchez and Soriano, 2011).

This exchange takes place in the context of the university that promotes it by playing the role of 'parent organisation' (Díez-Vial and Montoro-Sánchez, 2016). The exchange also results in the development of entrepreneurial clusters that leverage the efforts and synergies of universities' research policies (Berbegal-Mirabent et al., 2015).

Incubators in the academic context is another method, and one of the most widely adopted (Soetanto and Jack, 2016), which, with the support of government and industry, allow the development of spin-offs to be stimulated and entrepreneurship to be fostered in the academic community (Gilsing et al., 2010). Indeed, academic incubators play an essential role in the creation of value in university spin-offs (Berbegal-Mirabent et al., 2015), and the importance of these infrastructures in fostering university entrepreneurship is recognised, with particular relevance in the early stages of a university spin-off (Grimaldi and Grandi, 2005).

A university incubator can be defined as advanced professional facilities that provide human skills, and expertise (Corsi and Prencipe, 2016), which allow the aggregation of knowledge, technological development, and capital to enhance and accelerate the creation of new companies and the transfer of knowledge (Bruneel et al., 2012; Grimaldi and Grandi, 2005).

In particular, university incubators make it possible to overcome the limitations of highly specialised researchers by providing them not only with technical knowledge, but above all with managerial and commercial off competence (Vinig and Van Rijsbergen, 2010). Thus, the incubator consists of a university infrastructure that reduces the 'distance' between academia and the market, increasing the chances of success and growth potential of university spin-offs (Etzkowitz, 2002).

2.2 Entrepreneurial development of students' spin-offs

In the aforementioned context, it is from the university that university spin-offs receive the start-up incentive and the necessary resources, such as access to research facilities, temporary accommodation, management skills, legal protection, among others (Stenberg et al., 2014). When creating a university spin-off, the transfer of knowledge from the university to the new initiative is broader than the technological context (Soetanto and Van Geenhuizen, 2015). Indeed, at the university the conditions are in place to develop the personal contacts and networking from which can result in small or large progress such as joint research (Van Looy et al., 2011). However, within the set of required resources, management skills seem to be the most problematic (van Geenhuizen and Soetanto, 2009), noting that although academic spin-offs have privileged access to knowledge and research, they often lack other sources of income (Soetanto and Van Geenhuizen, 2015).

The need for market and business knowledge is associated with the lack of management skills, which play an essential role in overcoming difficulties related to the uncertainties of the environment and, simultaneously, to the management of the various

management tasks (Soetanto and Van Geenhuizen, 2015). Thus, the innovation performance of university spin-offs is related to their knowledge conversion capability, i.e. their ability to transform research and scientific knowledge into successful products and goods that can be effectively commercialised in the market (Sousa-Ginel et al., 2021).

Thus, university incubators play an essential role in the development of university spin-offs by providing training and mentoring as well as various business support services aimed at improving entrepreneurial skills and facilitating market access (Bøllingtoft and Ulhøi, 2005; Bergek and Norrman, 2008).Universities face several challenges in the development of university spin-offs. First of all, the very heterogeneity of the projects and stage of technology development requires different objectives, players, types of services and resources provided to the initiatives (Bruneel et al., 2012).

Furthermore, different classifications and typologies have been identified in the literature, which adds more complexity to this issue (Bergek and Norrman, 2008). For example, following the stage-based models view, Sousa-Ginel et al. (2021) recognises that university incubator models require different approaches depending on the phase in which the project is inserted and the idiosyncrasies of each type of company (Purchase et al., 2017). Stage-based models consider that

1 there are different stages in the growth of a company

2 stages follow a certain sequence

3 each stage is associated with a set of specific events which require different strategies, decision-making processes, capabilities, and resources (Van de Ven and Poole, 1995).

In this framework, it is natural that the types of support from universities are diverse. Soetanto and Jack (2016) establish a typology for the services provided by university incubators, namely:

1 providing basic entrepreneurial services such as accommodation, facilities and funding

2 facilitating social relationships with entrepreneurial agents and university contacts that enable access to market, financing and other research sources

3 providing entrepreneurship support such as mentoring, training and entrepreneurial coaching (Bergek and Norrman, 2008).

These supports are recognised for their role in increasing the resilience of projects and the growth potential of university spin-offs (Hannon and Chaplin, 2003).

Another important challenge is related to the governance model of academic spin-offs (Prencipe, 2016), which is dependent on the number of board members, the origin (external or internal) of the board and CEO-duality. In relation to the number of board members, it is found that a larger number of members facilitates access to a wider range of resources and knowledge especially in multifaceted contexts (Linck et al., 2008). A larger number of board members allow the spin-off to access more financial resources (Prencipe, 2016) and increase the ability to attract other high value-added researchers (Adams et al., 2010).

Concerning the origin of directors Prencipe (2016) recognises that external directors can play an important role by ensuring better control mechanisms and the defense of

shareholders' interests (Fama and Jensen, 1983). Outside directors can bring an important background in the financial or venture capital industry (Adams et al., 2010). Regarding CEO-duality, Prencipe (2016) suggests it is not a good option and that the positions of CEO and Chair of the board should be distinct, which increases the board's ability to monitor management (Fama and Jensen, 1983).

The issue of access to funding is central to university spin-offs (Wright et al., 2006). From a strategic point of view, the endowment of resources and capabilities are essential for the effectiveness of university innovation and spin-offs (Vinig and Van Rijsbergen, 2010), which in turn are dependent on access to funding, as well as to human capital and other organisational and technological skills available at the university (Rasmussen et al., 2015).

The university is in a privileged position to facilitate access to public (EU national) funding, which allows academic spin-offs to develop the technology from an early stage (Soetanto and Van Geenhuizen, 2015), which is particularly relevant given that other sources of investment will be unavailable at this stage (Myers, 1984) or will require a degree of control that may be impeding the future growth of the initiative (Rodeiro-Pazos et al., 2012). Further, Rørtveit et al. (2020) found that university spin-offs in the US are more likely to access external funding when compared to their European counterparts.

From a financial point of view, university support for spin-offs can take the form of direct or indirect support (Soetanto and Van Geenhuizen, 2015). The former case refers to situations in which funding from state or private fund is provided to spin-offs through the university's involvement. In the case of indirect support, it results from the university's involvement with potential investors or funders by promoting the image of the academic research developed by the spin-offs (Soetanto and Van Geenhuizen, 2015).

In the latter case, the university's role is very relevant given that university spin-offs, due to their novelty and possible disruptive character, do not (yet) benefit from an acceptance by investors nor from the credibility resulting from the existence of successful products or services in the market (Moray and Clarysse, 2005). It is in this sense that the connection to the university (and its reputation) contributes to university spin-offs, reinforcing their reputation and image with potential investors (Audretsch and Belitski, 2019).

3 Methodology

The SLR is a method used in several studies and different fields including management research, based on transparency, clarity, equality and accessibility (Thorpe et al., 2006). It's a valuable method used to investigate research in emergent fields and future research and directions (Junior and Godinho Filho, 2010; Govindan, 2013). The SLR process is applied openly in the same way that empirical research (Pittaway and Cope, 2007).

In the study, the SLR was following method according to Okoli and Schabram (2010) collecting data at Scopus database during initial period from 2004 to the end period of 2022 (considering from the first publication to the last publication) to support the problem of the study: *What are the digital technologies adopted by universities to support entrepreneurial students' spin-offs?* In complementary approach (Item 3.1) we addressed four research questions (RQs).

The search process was conducted in four steps (3.3–3.5) in terms of test filters across platform and the step (3.6), *'Publication Bias' to check the positive and negative results.*

3.1 Problem

What are the digital technologies adopted by universities to support entrepreneurial students' spin-offs?

3.2 Research questions

RQ1 What has been happening with publications during the period of analysis?

RQ2 What studies were covered in the journals?

RQ3 What is the main keyword used in the studies?

RQ4 Which country has the highest number of publications?

3.3 Search process: step 1

First, we used the Boolean method to select initial studies according to the main topic of the study, using the keywords 'digital innovation' and 'university', [TITLE-ABS-KEY ('digital innovation') AND TITLE-ABS-KEY ('university')]. We identified 98 studies in all 'document type' classification.

3.4 Inclusion process: step 2

In the second round we used the same Boolean method and keywords [TITLE-ABS-KEY ('digital innovation') AND TITLE-ABS-KEY ('university')] AND [(LIMIT-TO (DOCTYPE, 'ar')] AND [LIMIT-TO (LANGUAGE, 'English')] AND [LIMIT-TO (SRCTYPE, 'j')], including more classifications as 'doctype', only papers, 'language', only English, and 'type' only journals. We identify on this round 42 documents results (papers). The papers eligibility was confirmed reading the titles and abstracts to the initial analysis.

Table 1 Screening method

Period	***From 2004***	***To 2022***
Database Scopus	Screening	Publications
Search keywords	'Digital innovation' and 'university'	98
Inclusion criteria	'doctype', only papers, 'language', only English, and 'type' only journals	42
Screening	'Spin-off'	01

Source: Authors elaboration

3.5 Exclusion process: step 3

Finally, the same Boolean method and keywords [TITLE-ABS-KEY ('digital innovation') AND TITLE-ABS-KEY ('university')] AND TITLE-ABS-KEY ('Spin-off')) [LIMIT-TO (DOCTYPE, 'ar')] AND [LIMIT-TO (LANGUAGE, 'English')] AND [LIMIT-TO (SRCTYPE, 'j')] was applied to check the additional keyword involved on this search relation, 'spin-off'. Only 1 paper was identified and

consider in total result of 42 papers. In Table 1, the total of SLR resulted in 42 indexed scientific papers.

3.6 Publication Bias: step 4

In terms of 'bias' our strategy was to contacting experts on the topic according (Kitchenham, 2004) and ask if they know any similar or unpublished study like ours. Another strategy was check additional Boolean method and keywords [TITLE-ABS-KEY ('digital innovation') AND TITLE-ABS-KEY ('universities')] AND [LIMIT-TO (DOCTYPE, 'ar')] AND [LIMIT-TO (LANGUAGE, 'English')] AND [LIMIT-TO (SRCTYPE, 'j')]. The results were the same.

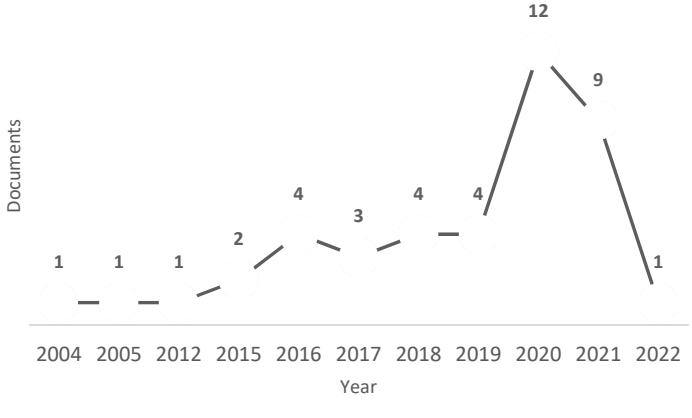
4 Results, discussion, and implications

In this section, we presented the answers for our RQs and the findings from the SLR (4.1–4.4), the answer for the main question (4.5), discussion (4.6) and implications (4.7).

4.1 What has been happening with publications during the period of analysis?

The papers were selected according to the existing period, considering the total number of publications, from 2004 to 2022 (February). The year 2020 presented the largest number of peer-reviewed papers on the proposed topic. The years 2016, 2018 and 2019 had four publications per year. The year 2015 presented only one publication per year. Those from 2012, 2005 and 2004 presented one publication per year. However, the years in the range from 2006 to 2011 had no publications. The same fact occurred in the years 2013 and 2014. Figure 1 presents the peer-reviewed publications throughout the analysed period.

Figure 1 Peer-reviewed publications



4.2 What studies were covered in the journals?

In Table 2, we present the name of the journals including the number of papers published. There are a total of 36 journals with one paper, one journal with one paper and one journal with four papers, for a total of 42 peer-reviewed papers. The principal journal with a greater number of papers published is Sustainability (Switzerland).

Table 2 Papers published per journal

Source title	*Number of papers published*
Sustainability (Switzerland)	4
Journal of E Learning and Knowledge Society	2
ABB Review	1
Ahuri Final Report	1
Australasian Journal of Educational Technology	1
Case Studies in the Environment	1
BMC Medical Education	1
BMJ Open	1
Cities	
Digital Library Perspectives	1
Education And Information Technologies	1
Electronic Journal Of Knowledge Management	1
Electronics and Communications in Japan, Part II: Electronics (English translation of Denshi Tsushin Gakkai Ronbunshi)	1
Herald Of The Russian Academy Of Sciences	1
Human Behavior And Emerging Technologies	1
IEEE Technology And Society Magazine	1
Information Japan	1
International Journal for Educational Integrity	1
International Journal of Disaster Risk Reduction	1
International Journal of Educational Research	1
International Journal of Engineering Research and Technology	1
International Journal of Management Education	1
JAMIA Open	1
JCO Clinical Cancer Informatics	1
Journal of African Media Studies	1
Journal of Information Communication and Ethics in Society	1
Journal of Microscopy and Ultrastructure	1
Journal of the Association for Information Science and Technology	1
Law and Economics Yearly Review	1
Mondo Digitale	1
Open Learning	1

Table 2 Papers published per journal (continued)

Source title	*Number of papers published*
Oral History Review	1
Organization Science	1
Plos One	1
Prometheus United Kingdom	1
Studies In Higher Education	1
Technology Analysis And Strategic Management	1
Turkish Online Journal of Educational Technology	1

In terms of publications, they were classified according to source title. *Sustainability Switzerland* with four publications [hydrogen economy development opportunities by inter-organisational digital knowledge networks; Medical electronic prescription for home respiratory care services (Pem-crd) at a Portuguese university tertiary care centre (2014–2018): A case study; Blockchain technology: Redefining trust for digital certificates and Twitter social network in university teaching. Digital Innovation Strategy for social responsibility]; *Journal of E-Learning and Knowledge Society* with two publications (Mooc design and heritage education. Developing soft and work-based skills in higher education students and Heritage education and initial teacher training: An international experience); others journals with one publication as follow: *ABB Review* (Digital innovation driven by university collaboration); Ahuri Final Report (Urban productivity and affordable rental housing supply in Australian cities and regions); *Australasian Journal of Educational Technology* (Blending for student engagement: Lessons learned for MOOCs and beyond); *BMC Medical Education* (Assessing the preparedness and feasibility of an e-learning pilot project for university level health trainees in Ghana: a cross-sectional descriptive survey); *BMJ Open* (Hearing Norton Sound: A community randomised trial protocol to address childhood hearing loss in rural Alaska); *Case Studies In The Environment* (Collaborative creation and implementation of a Michigan sustainability case on urban farming in Detroit); *Cities* (Living labs and vacancy in the neoliberal city); *Digital Library Perspectives* (Digital information literacy skills of Pakistani librarians: exploring supply-demand mismatches, adoption strategies and acquisition barriers); *Education And Information Technologies* (Higher education in a material world: Constraints to digital innovation in Portuguese universities and polytechnic institutes); *Electronic Journal Of Knowledge Management* (Teaching innovation to strengthen knowledge creation in a digital world); *Electronics and Communications in Japan, Part II: Electronics (English translation of Denshi Tsushin Gakkai Ronbunshi)* (A novel distance learning system for the TIDE project); *Herald Of The Russian Academy of Sciences* (The Impact of the COVID Crisis on the Innovative Potential of China's Internet Platforms); *Human Behavior And Emerging Technologies* (The current state and impact of Covid-19 on digital higher education in Germany); *IEEE Technology And Society Magazine* (The Life and Contributions of Countess Ada Lovelace: Unintended Consequences of Exclusion, Prejudice, and Stereotyping); *Information Japan* (The structural relationship of influence factors of personal information security awareness); *International Journal For Educational Integrity* (Networked participatory online learning design and challenges for academic integrity in

higher education); *International Journal of Disaster Risk Reduction* (Digital innovation for the post-earthquake 'second emergency phase' (SEP). Research experience in Central Italy); *International Journal Of Educational Research* (Higher education, graduate talent and the prospects for social mobility in China's innovation nation); *International Journal Of Engineering Research And Technology* (Implementation of Digital Educational Technologies in the Field of Automotive Electronics in Higher Education Institution); *International Journal of Management Education* (Data science in the business environment: Insight management for an Executive MBA); *JAMIA Open* (Establishing a multidisciplinary initiative for interoperable electronic health record innovations at an academic medical center); *JCO Clinical Cancer Informatics* (Contrast of Digital and Health Literacy Between IT and Health Care Specialists Highlights the Importance of Multidisciplinary Teams for Digital Health-A Pilot Study); *Journal Of African Media Studies* ('Hustler lives' and digital dilemmas in Kenya: Young men negotiating work opportunities, life aspirations and mobile phone use); *Journal Of Information Communication and Ethics In Society* (The future of the printed book in the era of technological advancement: an imperative for digital innovation and engagement); *Journal Of Microscopy and Ultrastructure* (Evaluation of curricular adaptations using digital transformation in a medical school in Arabian gulf during the COVID-19 pandemic); *Journal Of The Association For Information Science and Technology* (Digital innovations in poetry: Practices of creative writing faculty in online literary publishing); *Law And Economics Yearly Review* (Reimagining and re-designing the post-COVID-19 higher education organisations to address new challenges and responses for safe and effective teaching activities); *Mondo Digitale* (Innovation and entrepreneurship | [Innovazione e imprenditorialità]); *Open Learning* (The cathedral's ivory tower and the open education bazaar-catalysing innovation in the higher education sector); *Oral History Review* (Migration and Inclusive Transnational Heritage: Digital Innovation and the New Roots Latino Oral History Initiative); *Organization Science* (Reconfiguring boundary relations: Robotic innovations in pharmacy work); *Plos One* (Development and testing of an explorative BPM acceptance model: Insights from the COVID-19 pandemic); *Prometheus United Kingdom* (Commercialisation of knowledge in universities: The case of the creative industries); *Studies In Higher Education* (Higher education in troubled times: on the impact of Covid-19 in Italy); *Technology Analysis and Strategic Management* (Startups and the innovation ecosystem in Industry 4.0) and *Turkish Online Journal of Educational Technology* (A studio experience on parametric modelling approaches).

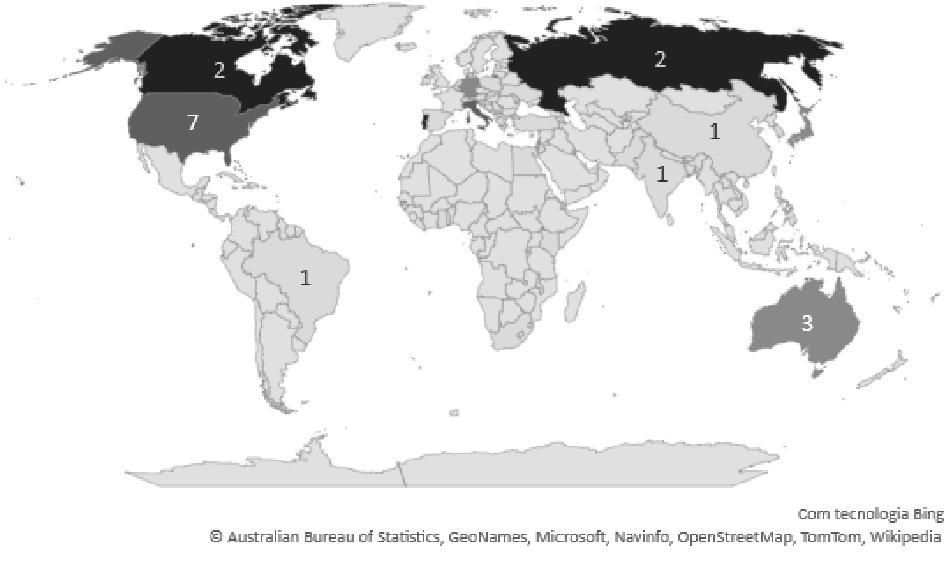
It is possible to conclude that has an interest on the 'digital innovation' topic in universities to support start-ups and spin offs. It reinforces the objective of this study and the relevance of the topic for future research.

4.3 What is the main keyword used in the studies?

In Figure 2, the frequency of keywords is presented considering the total number of published journals. Highlight for the keyword 'digital' with the number of 14 citations, corresponding to 6.45% of the total of 217 citations.

Figure 2 Keyword citation

Figure 3 Publications by country/territory



4.4 Which country has the highest number of publications?

In Figure 3, the analysis identified the countries/territories with the highest number of publications with emphasis on Italy and USA with seven publications each. The UK featured a total of five publications. Italy, Russian Federation and Japan presented two publications, while the other countries as Austria, Bahrain, Belgium, Brazil, China, Egypt, Ghana, Hungary, India, Ireland, Israel, Kenya, Netherlands, Pakistan, Poland,

Singapore, South Africa, South Korea, Spain, Switzerland, Turkey and Ukraine each presented only one publication.

The total of publications between countries with a frequency greater than five is equivalent to 19. The total of publications between countries with a frequency of more than two and less than three is equivalent to 15 publications and the total of publications between countries with a frequency equal to one, is equivalent to 22 publications. This demonstrates that most publications are present in a minority of countries.

4.5 What are the digital technologies adopted by universities to support entrepreneurial students' spin-offs?

To answer the main goal of the study, we reviewed all 42 papers to identifying the digital technologies adopted by universities to support entrepreneurial students' spin-offs. In Table 3, we presented the results of practices (digital technologies) adopted by universities. In terms of research method applied in the studies by authors, we have 37 quantitative, one qualitative-quantitative and four qualitative, Figure 4. In addition, considering the digital technologies/practices adopted by universities, we have three mobiles' technologies and two MOOCs studies using the same technology. The other studies worked with different technologies, having just one frequency for each study, Figure 5.

Table 3 Practices adopted by authors in universities studies

N	*Author*	*Research method*	*University/context*	*Digital technologies/practices*
1	Lu et al. (2020)	Qualitative	University of Winchester Business School	Data Science and Analytics
2	Ahmad and Looy	Quantitative	N/I	Digital Skills Set
3	Csedő et al.	Qualitative–Quantitative	N/I	P2X Technologies
4	Kawamoto et al.	Quantitative	University of Utah Health	Fast Healthcare Interoperability Resources (FHIR)
5	Ruggiero et al. (2021)	Quantitative	University of Camerino and the Japanese Keio University	Mobile
6	Pfob et al. (2021)	Quantitative	German Universities	Data Literacy
7	Gurran et al. (2022)	Quantitative	N/I	Smart City
8	Brown (2013)	Quantitative	China Universities	Social Mobility
9	Agasisti and Soncin (2021)	Quantitative	Politecnico di Milano	Redesign of Digital Services
10	Zawacki-Richter (2009)	Quantitative	German Universities	Remote Teaching
11	Alves et al. (2020)	Quantitative	Portugal – Home Respiratory Care (HRC)	Medical Electronic Prescription for Home Respiratory Care tool (PEM-CRD)

Table 3 Practices adopted by authors in universities studies (continued)

N	*Author*	*Research method*	*University/context*	*Digital technologies/practices*
12	Alhassan (2020)	Quantitative	Ghana's Public Universities	e-Learning
13	Danilin (2020)	Quantitative	China Uninersity	Cloud Solutions
14	Capece et al. (2020)	Quantitative	The University of Rome 'Tor Vergata'	Blockcerts
15	Vicente et al. (2020)	Quantitative	Portuguese Universities and Polytechnic Institutes	Digital Infrastructure
16	Kumar et al. (2020)	Qualitative	Medical School in Arabian Gulf	Modular Object-Oriented Dynamic Learning Environment
17	Khan (2020)	Quantitative	Pakistani Librarians	Digital Information Literacy (DIL)
18	TorresBarzabal et al. (2022)	Quantitative	N/I	Social Networks
19	Rabin et al. (2018)	Quantitative	N/I	Predict Analyse
20	Nyambane (2021)	Quantitative	Technical University of Kenya	E-Book
21	Pellegrini et al. (2018)	Quantitative	European and USA Universities	Blended Learning
22	Samedov et al. (2020)	Quantitative	N/I	Digital Educational Resources
23	Rocha et al. (2021)	Quantitive	C2i, International Innovation Center (Startups)	Industry 4.0
24	Gill et al. (2020)	Quantitative	University of North Carolina at Chapel Hill	Internet-Based Digital Information System and Bilingual Website
25	Van den Berg and Raubenheimer (2015)	Quantitative	University in South Africa	Framework for Digital Innovation Skills.
26	Emmett (2002)	Quantitative	Duke University	Hearing Screen and New Mobile Health (mHealth)
27	Boone et al. (2018)	Quantitative	University of Michigan School for Environment and Sustainability (SEAS)	Experiential Learning
28	Cardullo et al. (2018)	Quantitative	N/I	Crowdsourcing, and Tech-Led Regeneration Initiatives.
29	Stief et al. (2018)	Quantitative	Imperial College London	Data-Driven
30	Poce et al. (2020)	Quantitative	Roma Tre University Museum Education Centre	Mobile

Table 3 Practices adopted by authors in universities studies (continued)

N	*Author*	*Research method*	*University/context*	*Digital technologies/practices*
31	Tufte and Chapman (1967)	Quantitative	N/I	Mobile
32	Kim and Hur (2017)	Quantitative	N/I	Information Security
33	Poce et al. (2020)	Quantitative	University Roma TRE	MOOCs
34	Coe and Ferworn (2016)	Qualitative	N/I	Thinking Machine (AI)
35	O'Connell	Quantitative	Charles Sturt University's Master of Education	Game-Based Learning
36	Duca and Cristinelli (2011)	Quantitative	N/I	Deep Learning
37	Fleming-May and Green (2016)	Qualitative	Faculty from North American Institutions	Communities of Practice
38	İyican et al. (1980)	Quantitative	Karabük University	BIM (Building Information Modeling) and CAD (Computer Aided Design)
39	Montgomery et al. (2015)	Quantitative	N/I	MOOCs
40	Barrett and Whyte (1982)	Quantitative	University of Chicago Press	Digital Inscriptions (Robot)
41	Yagi et al. (2016)	Quantitative	Kyoto University and UCLA	Distance Learning System (DLS)
42	Hearn et al. (2004)	Qualitativo	N/I	Intellectual Property Protection

Figure 4 Research method

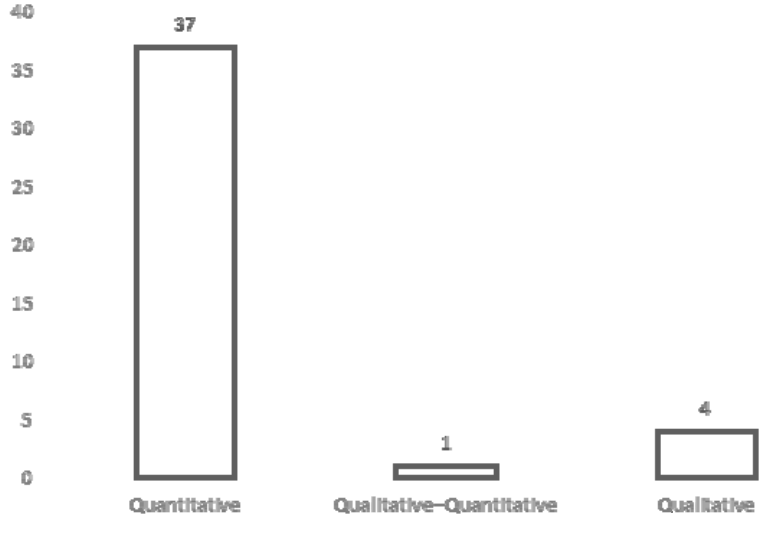
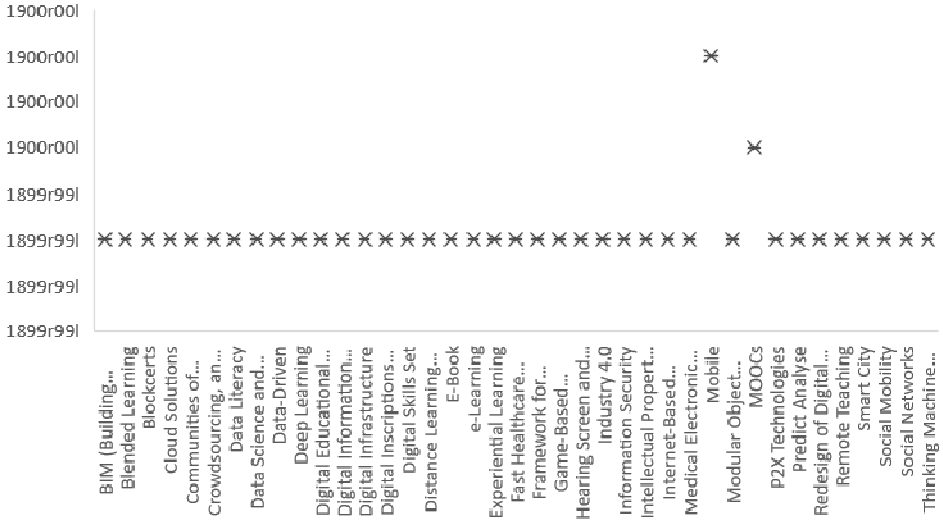


Figure 5 Digital technologies/practices adopted



4.6 Discussion

A 'digital technology' could be considered as the main resource to transform students in entrepreneurs to develop spin-offs. It depends on the university, the technology and the skills adopted and combined into an economic development. For Kawamoto et al. (2021) technology is not the most important element on this process to support students, but some practices adopted before implement the technology with success. Its mean that, people behaviour (skills) are more important than technology developing.

In terms of technologies, universities adopted several based on learning process, giving the autonomy for the students, e.g., MOOCs, e-Learning, Mobile, Data Analytics, and others, Figure 5. All these technologies were adopted for hight universities around the world, e.g., University of Winchester Business School, Polytechnic di Milano, Medical School in Arabian Gulf, University of North Carolina at Chapel Hill, Duke University, University of Michigan School for Environment and Sustainability (SEAS), Imperial College London, University of Chicago Press, Kyoto University, UCLA, and others, Table 3.

In additional, universities identified in research focus studies in the areas of sustainability, health, technology, and learning, with a greater emphasis on the quantitative method approach, Figure 4.

Regarding the highest number of publications per country, we identify Italy and USA with seven publications each, Figure 3. These seven technologies adopted in the studies for USA was focused on

a 'electronic health'

b 'teaching activities'

c 'information system'

d 'school hearing screening'

e ‘experiential learning’

f ‘publishing in online’

g ‘robotic innovations’.

Consequently, the Italy universities adopted in terms of technologies topics,

a ‘mobile’

b ‘redesign of services’

c ‘certificates’

d ‘learning experiences’

e ‘web app’

f ‘MOOCs’

g ‘deep technical knowledge’.

According to Ahmad et al. (2021) emerging technologies is the main way to get the transformation of universities. For instance, Csedő et al. (2021) applied the emergence technology named power-to-X (P2X) considering crucial to the economic development. But this technology adopted was not implemented in large scale.

All these technologies were based on the ‘digital’ and ‘study’ conceptions and represented in Figure 2 as main key-word analysis. It provides the relevance of the themes ‘digital innovation’ and ‘university’ according to our methodology, Section 3. Finally, o long part of the studies in Europe were funding by Erasmus+ projects.

4.7 Implications

The main implications of this research regarding theory are focused on the understanding of the main concepts under study, namely, entrepreneurship and university spin-offs, and a systematisation of the models of innovation to be applied in university spin-off context. In synthesis, this study makes theoretical contributions because it analyses the concepts underlined before and builds a framework for university spin-offs.

The practical implications of this research are mostly to understand the trends of this type of entrepreneurship in universities, and it also can give practical understanding for the students and also for the entrepreneurship infrastructures that the universities create to potentiate new business emerged in those infrastructures, but developed outside of the university boundaries, sometimes creating new value, and assuming high level positions in the markets.

Moreover, from the SLR emerged the main research attributes being studied in the past years regarding technologies and practices in university spin-offs, which can give a vision about the possible topic for future research, but mainly the technologies and practices to be adopted for the new potential spin-offs.

In respect to the type of emergent and trendy business identified there are topics related to data science and analytics, smart cities, redesign of digital services; remote teaching, social networks; predict analyse; industry 4.0; crowdsourcing, and information security.

The skills identified in the research can give directions for further development of digital skills, data literacy, digital information literacy, digital innovation skills and knowledge bout intellectual property protection.

5 Conclusions and limitations

5.1 Conclusions

These research gives indications about the main technologies used in university spin-off context, namely, P2X Technologies, healthcare interoperability resources, mobile technologies, cloud solutions, modular object-oriented internet-based digital information system, mobile health (mHealth); artificial intelligence, building information modelling, computer aided design, robots, and distance learning system.

Entrepreneurship is part of the priority agenda for public policies in addressing social and economic challenges. In this regard this research has made a systematisation of the main technologies used by students in their university entrepreneurship endeavours, leading to the spin-off of the business to reach the real market competition.

The main recommendation for policy is the need to focus on more the student's education and help to fund projects to create awareness regarding the role of entrepreneurs in creating employment and increasing the quality of life of the citizens and the development of local communities.

The lessons learnt based on the entrepreneurship policy can give awareness to the universities to use the tools and the funding that drives from Public Policies to University to create entrepreneurship infrastructures for their students. The economic return of investment done universities on entrepreneurship infrastructures to help the students to develop their entrepreneurial capabilities and capacities is high and can be achieved in the short and medium-term, and potentiated when they translate their business to the real market.

The public policies can help social entrepreneurship to gain more visibility and recognition in universities and their work with students, developing early links with the market and supporting the spin-off process with gains to all the involved in the process. Public policies can also support and promote new avenues for university entrepreneurship spin-offs.

5.2 Limitations

This study has some limitations, namely, the analysis is limited to the databases used in the research of the articles, which could skew the results, and could prevent us from identifying possible technologies that, some for reason, are not present in the studies analysed. The analysis does not validate if the conceptual framework is specific to university spin-offs regarding based-technologies business or if it is also applied to other type of entrepreneurship areas.

The SLR is conditioned by the search criteria, and it does not explicit the transition process of the university spin-off for a better understanding of the use of the technologies in the entrepreneurship and university spin-off process, and not only regarding the specificities of the business created by the students. As this is an important step of the university spin-off process it should be studied in the future.

References

Adams, R.B., Hermalin, B.E. and Weisbach, M.S. (2010) 'The role of boards of directors in corporate governance: a conceptual framework and survey', *Journal of Economic Literature*, Vol. 48, No. 1, pp.58–107.

Agasisti, T. and Soncin, M. (2021) 'Higher education in troubled times: on the impact of Covid-19 in Italy', *Studies in Higher Education*, Vol. 46, No. 1, pp.86–95.

Ahmad, A.R., Jameel, A.S. and Raewf, M. (2021) 'Impact of social networking and technology on knowledge sharing among undergraduate students', *International Business Education Journal*, Vol. 14, No. 1, pp.1–16.

Ahmad, T. and Van Looy, A. (2021) 'Development and testing of an explorative BPM acceptance model: Insights from the COVID-19 pandemic', *PloS One*, Vol. 16, No. 11, p.e0259226.

Algieri, B., Aquino, A. and Succurro, M. (2013) 'Technology transfer offices and academic spin-off creation: the case of Italy', *The Journal of Technology Transfer*, Vol. 38, No. 4, pp.382–400.

Alhassan, R.K. (2020) 'Assessing the preparedness and feasibility of an e-learning pilot project for university level health trainees in Ghana: a cross-sectional descriptive survey', *BMC Medical Education*, Vol. 20, No. 1, pp.1–10.

Almeida, F. (2021) 'Human resource management practices at university spin-offs', *International Journal of Organizational Analysis*.

Alves, R., Caneiras, C., Santos, A.I., Barbosa, P., Cardoso, J., Caseiro, P. and Escoval, A. (2020) 'Medical electronic prescription for home respiratory care services (PEM-CRD) at a Portuguese University Tertiary Care Centre (2014–2018): a case study', *Sustainability*, Vol. 12, No. 23, p.9859.

Audretsch, D.B. and Belitski, M. (2019) 'Science parks and business incubation in the United Kingdom: evidence from university spin-offs and staff start-ups', in *Science and Technology Parks and Regional Economic Development*, pp.99–122, Palgrave Macmillan, Cham.

Barrett, R.E. and Whyte, M.K. (1982) 'Dependency theory and Taiwan: analysis of a deviant case', *American Journal of Sociology*, Vol. 87, No. 5, pp.1064–1089.

Berbegal-Mirabent, J., Ribeiro-Soriano, D.E. and García, J.L.S. (2015) 'Can a magic recipe foster university spin-off creation?', *Journal of Business Research*, Vol. 68, No. 11, pp.2272–2278.

Bergek, A. and Norrman, C. (2008) 'Incubator best practice: a framework', *Technovation*, Vol. 28, Nos. 1–2, pp.20–28.

Bøllingtoft, A. and Ulhøi, J.P. (2005) 'The networked business incubator – leveraging entrepreneurial agency?', *Journal of Business Venturing*, Vol. 20, No. 2, pp.265–290.

Boone, L.A.U.R.E.N., Ultee, L.I.Z.Z., Waisanen, E., Newell, J.P., Thorne, J.A. and Hardin, R. (2018) 'Collaborative creation and implementation of a Michigan sustainability case on urban farming in Detroit', *Case Stud. Environ.*, Vol. 2, No. 1, pp.1–13.

Brown, P. (2013) 'Education, opportunity and the prospects for social mobility', *British Journal of Sociology of Education*, Vol. 34, Nos. 5–6, pp.678–700.

Bruneel, J., Ratinho, T., Clarysse, B. and Groen, A. (2012) 'The evolution of business incubators: comparing demand and supply of business incubation services across different incubator generations', *Technovation*, Vol. 32, No. 2, pp.110–121.

Capece, G., Levialdi Ghiron, N. and Pasquale, F. (2020) 'Blockchain technology: redefining trust for digital certificates', *Sustainability*, Vol. 12, No. 21, p.8952.

Carayannis, E.G., Rogers, E.M., Kurihara, K. and Allbritton, M.M. (1998) 'High-technology spin-offs from government R&D laboratories and research universities', *Technovation*, Vol. 18, No. 1, pp.1–11.

Cardullo, P., Kitchin, R. and Di Feliciantonio, C. (2018) 'Living labs and vacancy in the neoliberal city', *Cities*, Vol. 73, pp.44–50.

Clarysse, B., Wright, M., Bruneel, J. and Mahajan, A. (2014) 'Creating value in ecosystems: crossing the chasm between knowledge and business ecosystems', *Research Policy*, Vol. 43, No. 7, pp.1164–1176.

Coe, I.R. and Ferworn, A. (2016) 'The life and contributions of countess Ada Lovelace: Unintended consequences of exclusion, prejudice, and stereotyping', *IEEE Technology and Society Magazine*, Vol. 35, No. 4, pp.46–49.

Corsi, C. and Prencipe, A. (2016) 'Improving innovation in university spin-offs: the fostering role of university and region', *Journal of Technology Management & Innovation*, Vol. 11, No. 2, pp.13–21.

Csedő, Z., Zavarkó, M., Vaszkun, B. and Koczkás, S. (2021) 'Hydrogen economy development opportunities by inter-organizational digital knowledge networks', *Sustainability*, Vol. 13, No. 16, p.9194.

Danilin, I.V. (2020) 'The impact of the covid crisis on the innovative potential of China's internet platforms', *Herald of the Russian Academy of Sciences*, Vol. 90, No. 6, pp.779–788.

Di Gregorio, D. and Shane, S. (2003) 'Why do some universities generate more start-ups than others?', *Research Policy*, Vol. 32, No. 2, pp.209–227.

Díez-Vial, I. and Montoro-Sánchez, Á. (2016) 'How knowledge links with universities may foster innovation: the case of a science park', *Technovation*, Vol. 50, pp.41–52 [online] https://www.sciencedirect.com/science/article/pii/S0166497215000620?via%3Dihub.

Duca, M.G.L. and Cristinelli, A. (2011) 'Riconoscere le voci verbali: indagine su una categoria complessa', *Grammatica a scuola*, Vol. 153.

Emmett, R.B. (2002) 'Surfing the past: the role of the internet in the future of the history of economics', *History of Political Economy*, Vol. 34, No. 5, pp.245–260.

Etzkowitz, H. (2002) 'Incubation of incubators: innovation as a triple helix of university-industry-government networks', *Science and Public Policy*, Vol. 29, No. 2, pp.115–128.

Fama, E.F. and Jensen, M.C. (1983) 'Separation of ownership and control', *The Journal of Law and Economics*, Vol. 26, No. 2, pp.301–325.

Fernández-López, S., Rodeiro-Pazos, D., Rodríguez-Gulías, M.J. and Nogueira-Moreiras, M.A. (2022) 'Sustainable university entrepreneurship: revisiting firm growth patterns', *Business Strategy and the Environment*, Vol. 31, No. 4, pp.1334–1346.

Fleming-May, R.A. and Green, H. (2016) 'Digital innovations in poetry: Practices of creative writing faculty in online literary publishing', *Journal of the Association for Information Science and Technology*, Vol. 67, No. 4, pp.859–873.

Gill, H., Vos, J., Villa-Torres, L. and Ramirez, M.S. (2020) 'Migration and inclusive transnational heritage: digital innovation and the new roots Latino oral history initiative', *The Oral History Review*.

Gilsing, V.A., Van Burg, E. and Romme, A.G.L. (2010) 'Policy principles for the creation and success of corporate and academic spin-offs', *Technovation*, Vol. 30, No. 1, pp.12–23.

González, C., López, D., Calle-Arango, L., Montenegro, H. and Clasing, P. (2022) 'Chilean university students' digital learning technology usage patterns and approaches to learning', *ECNU Review of Education*, Vol. 5, No. 1, pp.37–64.

Govindan, K. (2013) 'Vendor-managed inventory: a review based on dimensions', *International Journal of Production Research*, Vol. 51, No. 13, pp.3808–3835.

Grimaldi, R. and Grandi, A. (2005) 'Business incubators and new venture creation: an assessment of incubating models', *Technovation*, Vol. 25, No. 2, pp.111–121.

Gurran, N., Maalsen, S. and Shrestha, P. (2022) 'Is 'informal'housing an affordability solution for expensive cities? Evidence from Sydney, Australia', *International Journal of Housing Policy*, Vol. 22, No. 1, pp.10–33.

Hannon, P.D. and Chaplin, P. (2003) 'Are incubators good for business? Understanding incubation practice – the challenges for policy', *Environment and Planning C: Government and Policy*, Vol. 21, No. 6, pp.861–881.

Hearn, G., Cunningham, S. and Ordonez, D. (2004) 'Commercialisation of knowledge in universities: the case of the creative industries', *Prometheus*, Vol. 22, No. 2, pp.189–200.

Iyican, L., Bayazitoglu, Y. and Witte, L.C. (1980) 'An analytical study of natural convective heat transfer within a trapezoidal enclosure'.

Johansson, M., Jacob, M. and Hellström, T. (2005) 'The strength of strong ties: university spin-offs and the significance of historical relations', *The Journal of Technology Transfer*, Vol. 30, No. 3, pp.271–286.

Junior, M.L. and Godinho Filho, M. (2010) 'Variations of the kanban system: literature review and classification', *International Journal of Production Economics*, Vol. 125, No. 1, pp.13–21.

Kawamoto, K., Kukhareva, P.V., Weir, C., Flynn, M.C., Nanjo, C.J., Martin, D.K., ... and Del Fiol, G. (2021) 'Establishing a multidisciplinary initiative for interoperable electronic health record innovations at an academic medical center', *JAMIA Open*, Vol. 4, No. 3, p.ooab041.

Khan, A. (2020) 'Digital information literacy skills of Pakistani librarians: exploring supply-demand mismatches, adoption strategies and acquisition barriers', *Digital Library Perspectives*, Vol. 36, No. 2, pp.167–189.

Kim, Y. and Hur, Y. (2017) 'The structural relationship of influence factors of personal information security awareness', *International Information Institute (Tokyo). Information*, Vol. 20, No. 8B, pp.3967–5974.

Kitchenham, B. (2004) *Procedures for Performing Systematic Reviews*, Vol. 33, pp.1–26, Keele University, Keele, UK.

Kumar, A.P., Al Ansari, A.M., Shehata, M.H.K., Tayem, Y.I.Y., Arekat, M.R.K., Kamal, A.A.M. and Tabbara, K.S. (2020) 'Evaluation of curricular adaptations using digital transformation in a medical school in Arabian Gulf during the COVID-19 pandemic', *Journal of Microscopy and Ultrastructure*, Vol. 8, No. 4, p.186.

Lejpras, A. (2014) 'How innovative are spin-offs at later stages of development? Comparing innovativeness of established research spin-offs and otherwise created firms', *Small Business Economics*, Vol. 43, No. 2, pp.327–351.

Linck, J.S., Netter, J.M. and Yang, T. (2008) 'The determinants of board structure', *Journal of Financial Economics*, Vol. 87, No. 2, pp.308–328.

Lu, J., Cairns, L. and Smith, L. (2020) 'Data science in the business environment: customer analytics case studies in SMEs', *Journal of Modelling in Management*.

McAdam, M. and McAdam, R. (2008) 'High tech start-ups in University Science Park incubators: the relationship between the start-up's lifecycle progression and use of the incubator's resources', *Technovation*, Vol. 28, No. 5, pp.277–290.

Mikheev, A., Serkina, Y. and Vasyaev, A. (2021) 'Current trends in the digital transformation of higher education institutions in Russia', *Education and Information Technologies*, Vol. 26, No. 4, pp.4537–4551.

Minguillo, D., Tijssen, R. and Thelwall, M. (2015) 'Do science parks promote research and technology? A scientometric analysis of the UK', *Scientometrics*, Vol. 102, No. 1, pp.701–725.

Montgomery, A.P., Hayward, D.V., Dunn, W., Carbonaro, M. and Amrhein, C.G. (2015) 'Blending for student engagement: lessons learned for MOOCs and beyond', *Australasian Journal of Educational Technology*, Vol. 31, No. 6.

Montoro-Sánchez, Á. and Soriano, D.R. (2011) 'Human resource management and corporate entrepreneurship', *International Journal of Manpower*.

Moray, N. and Clarysse, B. (2005) 'Institutional change and resource endowments to science-based entrepreneurial firms', *Research Policy*, Vol. 34, No. 7, pp.1010–1027.

Myers, S.C. (1984) 'Finance theory and financial strategy', *Interfaces*, Vol. 14, No. 1, pp.126–137.

Nikou, S. and Aavakare, M. (2021) 'An assessment of the interplay between literacy and digital technology in higher education', *Education and Information Technologies*, Vol. 26, No. 4, pp.3893–3915.

Nosella, A. and Grimaldi, R. (2009) 'University-level mechanisms supporting the creation of new companies: an analysis of Italian academic spin-offs', *Technology Analysis & Strategic Management*, Vol. 21, No. 6, pp.679–698.

Nyambane, R. (2021) 'The future of the printed book in the era of technological advancement: an imperative for digital innovation and engagement', *Journal of Information, Communication and Ethics in Society*.

O'Connell, J. (2016) 'Networked participatory online learning design and challenges for academic integrity in higher education', *International Journal for Educational Integrity*, Vol. 12, No. 1, pp.1–15.

O'shea, R.P., Allen, T.J., Chevalier, A. and Roche, F. (2005) 'Entrepreneurial orientation, technology transfer and spinoff performance of US universities', *Research Policy*, Vol. 34, No. 7, pp.994–1009.

Okoli, C. and Schabram, K. (2010) 'A guide to conducting a systematic literature review of information systems research'. *Sprouts: Working Papers on Information Systems*, Vol. 10, No. 26 [online] http://sprouts.aisnet.org/10-26.

Pellegrini, G., Ardigò, D., Milazzo, G., Iotti, G., Guatelli, P., Pelosi, D. and De Luca, M. (2018) 'Navigating market authorization: the path holoclar took to become the first stem cell product approved in the European Union', *Stem Cells Translational Medicine*, Vol. 7, No. 1, pp.146–154.

Pfob, A., Sidey-Gibbons, C., Schuessler, M., Lu, S.C., Xu, C., Dubsky, P. and Heil, J. (2021) 'Contrast of digital and health literacy between IT and health care specialists highlights the importance of multidisciplinary teams for digital health – a pilot study', *JCO Clinical Cancer Informatics*, Vol. 5, pp.734–745.

Pirnay, F., Surlemont, B. and Nlemvo, F. (2003) 'Toward a typology of university spin-offs', *Small Business Economics*, Vol. 21, No. 4, pp.355–369.

Pittaway, L. and Cope, J. (2007) 'Entrepreneurship education: a systematic review of the evidence', *International Small Business Journal*, Vol. 25, No. 5, pp.479–510.

Poce, A., Maria Rosaria, R., Amenduni, F., De Medio, C. and Valente, M. (2020) 'Using different learning methodologies and tools to exploit the educational impact of a University Art Collection: a pilot phase at Roma Tre University (IT)'.

Prencipe, A. (2016) 'Board composition and innovation in university spin-offs: evidence from the Italian context', *Journal of Technology Management & Innovation*, Vol. 11, No. 3, pp.33–39.

Purchase, S., Kum, C. and Olaru, D. (2017) 'An analysis of technical and commercialization paths for an innovation trajectory', *Journal of Business & Industrial Marketing*, Vol. 32, No. 6, pp.848–863

Rabin, J.S., Schultz, A.P., Hedden, T., Viswanathan, A., Marshall, G.A., Kilpatrick, E. and Chhatwal, J.P. (2018) 'Interactive associations of vascular risk and β-amyloid burden with cognitive decline in clinically normal elderly individuals: findings from the Harvard Aging Brain Study', *JAMA Neurology*, Vol. 75, No. 9, pp.1124–1131.

Rapanta, C., Botturi, L., Goodyear, P., Guàrdia, L. and Koole, M. (2021) 'Balancing technology, pedagogy and the new normal: Post-pandemic challenges for higher education', *Postdigital Science and Education*, Vol. 3, No. 3, pp.715–742.

Rasmussen, E., Mosey, S. and Wright, M. (2015) 'The transformation of network ties to develop entrepreneurial competencies for university spin-offs', *Entrepreneurship & Regional Development*, Vol. 27, Nos. 7–8, pp.430–457.

Rocha, C., Quandt, C., Deschamps, F., Philbin, S. and Cruzara, G. (2021) 'Collaborations for digital transformation: case studies of Industry 4.0 in Brazil', *IEEE Transactions on Engineering Management*.

Rodeiro-Pazos, D., López, S.F., González, L.O. and Sandiás, A.R. (2012) 'A resource-based view of university spin-off activity: New evidence from the Spanish case', *Revista Europea de Dirección y Economía de la Empresa*, Vol. 21, No. 3, pp.255–265.

Rodríguez-Gulías, M.J., Rodeiro-Pazos, D. and Fernández-López, S. (2016) 'The regional effect on the innovative performance of university spin-offs: a multilevel approach', *Journal of the Knowledge Economy*, Vol. 7, No. 4, pp.869–889.

Rørtveit, K., Saetre Hansen, B., Joa, I., Lode, K. and Severinsson, E. (2020) 'Qualitative evaluation in nursing interventions – a review of the literature', *Nursing Open*, Vol. 7, No. 5, pp.1285–1298.

Ruggiero, R., Kobayashi, H., Cognoli, R. and Kaito, S. (2021) 'Digital innovation for the post-earthquake 'second emergency phase' (SEP). Research experience in Central Italy', *International Journal of Disaster Risk Reduction*, Vol. 61, p.102293.

Samedov, M., Deryagin, A., Sahabicv, I., Pahuta, M., Rebenok, V. and Zakirova, N. (2020) 'Implementation of digital educational technologies in the field of automotive electronics in higher education institution'.

Selwyn, N., O'Neill, C., Smith, G., Andrejevic, M. and Gu, X. (2021) 'A necessary evil? The rise of online exam proctoring in Australian universities', *Media International Australia*, [online] https://journals.sagepub.com/doi/full/10.1177/1329878X211005862.

Soetanto, D. and Jack, S. (2016) 'The impact of university-based incubation support on the innovation strategy of academic spin-offs', *Technovation*, Vol. 50, pp.25–40 [online] https://www.sciencedirect.com/science/article/pii/S0166497215000759?casa_token=5kV1wz9UAjoAAAAA:fgj4u5pEh0jKQOA4AFM_rsx0JGbSqOhqMGYAUiLH272ciGLa9fr8fH690m_ue1PQOmfwuHX2Ezs.

Soetanto, D. and Van Geenhuizen, M. (2015) 'Getting the right balance: university networks' influence on spin-offs' attraction of funding for innovation', *Technovation*, Vol. 36, pp.26–38 [online] https://www.sciencedirect.com/science/article/pii/S0166497214001576?casa_token=PSkMK8FUXmoAAAAA:VV-lCeSi9sVtKY1Y_G1CUFJ4k4hYT_EV1TehTu6ZjRi2Ke0T3i24BN4ZPMg2WjyrTaeOaJ9D44M.

Son, H., Chung, Y. and Yoon, S. (2022) 'How can university technology holding companies bridge the valley of death? Evidence from Korea', *Technovation*, Vol. 109, p.102158 [online] https://www.sciencedirect.com/science/article/pii/S0166497218305716?casa_token=gXAmcoT-htIAAAAA:zL_ElOY30tUSUcdaxXWA3WPshaxnRZ8fgq-NxFrxyU-e-_UEFp1kqbmYsUAq3BEmv4PhEuKLL1w.

Sousa-Ginel, E., Franco-Leal, N. and Camelo-Ordaz, C. (2021) 'Knowledge conversion capability and networks as drivers of innovation in academic spin-offs', *Journal of Engineering and Technology Management*, Vol. 59, p.101615 [online] https://www.sciencedirect.com/science/article/pii/S0923474821000047?casa_token=MW1ceIg2DjQAAAAA:g_dI_WlTQPl_GRrtfUUbVpqaPdzwK89BmMCQZJbGjfvWAGlHCvTqGSkWBQ_BhosBgcPuYzIDwEE.

Stenberg, K., Karlsson, L., Pitkaniemi, H. and Maaranen, K. (2014) 'Beginning student teachers' teacher identities based on their practical theories', *European Journal of Teacher Education*, Vol. 37, No. 2, pp.204–219.

Stief, A., Ottewill, J.R., Tan, R. and Cao, Y. (2018) 'Process and alarm data integration under a two-stage Bayesian framework for fault diagnostics', *IFAC-PapersOnLine*, Vol. 51, No. 24, pp.1220–1226.

Thorpe, R., Holt, R., Pittaway, L. and Macpherson, A. (2006) 'Knowledge within small and medium sized firms: a systematic review of the evidence', *International Journal of Management Reviews*, Vol. 7, No. 4, pp.257–81.

Torres Barzabal, M.L., Martínez Gimeno, A., Jaén Martínez, A. and Hermosilla Rodríguez, J.M. (2022) 'La percepción del profesorado de la Universidad Pablo de Olavide sobre su Competencia Digital Docente', Pixel-Bit.

Treibich, T., Konrad, K. and Truffer, B. (2013) 'A dynamic view on interactions between academic spin-offs and their parent organizations', *Technovation*, Vol. 33, No. 12, pp.450–462.

Tufte, O.N. and Chapman, P.W. (1967) 'Electron mobility in semiconducting strontium titanate', *Physical Review*, Vol. 155, No. 3, p.796.

Van de Ven, A.H. and Poole, M.S. (1995) 'Explaining development and change in organizations', *Academy of Management Review*, Vol. 20, No. 3, pp.510–540.

Van den Berg, L. and Raubenheimer, J. (2015) 'Food insecurity among students at the University of the Free State, South Africa', *South African Journal of Clinical Nutrition*, Vol. 28, No. 4, pp.160–169.

Van Geenhuizen, M. and Soetanto, D.P. (2009) 'Academic spin-offs at different ages: a case study in search of key obstacles to growth', *Technovation*, Vol. 29, No. 10, pp.671–681.

Van Looy, B., Landoni, P., Callaert, J., Van Pottelsberghe, B., Sapsalis, E. and Debackere, K. (2011) 'Entrepreneurial effectiveness of European universities: an empirical assessment of antecedents and trade-offs', *Research Policy*, Vol. 40, No. 4, pp.553–564.

Vicente, P.N., Lucas, M., Carlos, V. and Bem-Haja, P. (2020) 'Higher education in a material world: constraints to digital innovation in Portuguese universities and polytechnic institutes', *Education and Information Technologies*, Vol. 25, No. 6, pp.5815–5833.

Vinig, T. and van Rijsbergen, P. (2010) 'University technology transfer: comparative study of US, European and Australian universities', in *Handbook of Research on High-Technology Entrepreneurs*., Edward Elgar Publishing [online] https://www.elgaronline.com/view/edcoll/9781847209498/9781847209498.00020.xml.

Walter, A., Auer, M. and Ritter, T. (2006) 'The impact of network capabilities and entrepreneurial orientation on university spin-off performance', *Journal of Business Venturing*, Vol. 21, No. 4, pp.541–567.

Wright, M., Lockett, A., Clarysse, B. and Binks, M. (2006) 'University spin-out companies and venture capital', *Research Policy*, Vol. 35, No. 4, pp.481–501.

Yagi, M., Hosogane, N., Watanabe, K., Asazuma, T., Matsumoto, M. and Keio Spine Research Group (2016) 'The paravertebral muscle and psoas for the maintenance of global spinal alignment in patient with degenerative lumbar scoliosis', *The Spine Journal*, Vol. 16, No. 4, pp.451–458.

Zawacki-Richter, O. (2009) 'Research areas in distance education: a Delphi study', *International Review of Research in Open and Distributed Learning*, Vol. 10, No. 3.