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REVIEW

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# Emerging best strategies and capabilities for university–industry cooperation: opportunities for MSMEs and universities to improve collaboration. A literature review 2000–2023

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## Abstract

Continuous technological development, digitalization, Industry 4.0, robotization, virtualization, and related investments in new types of physical assets are imposing increasing financial and intellectual demands on micro, small, and medium-sized enterprises (MSMEs). While fast technological development and rapid societal change make maintenance of a successful competitive edge ever more challenging, they also offer considerable potential for differentiation. In the area of networking and outside resources, MSMEs can utilize external resources and cooperate and collaborate with higher educational institutions (HEI) to boost their innovations pipeline and develop new technologies and processes to generate commercial products/services and improve their service offering. This research explores existing highly effective university–industry collaboration (UIC) models and seeks explanations for their success by examining the literature from the point of view of establishing successful relationships, emphasizing the importance of critical drivers for success. Our work synthesizes current knowledge of best practices based on a comparative analysis of practical collaboration. In the work, we identify eight popular and successful collaboration models: research and development partnerships, internships and co-op programs, knowledge transfer programs, entrepreneurship, and incubation programs, sponsored projects and grants, joint ventures and licensing agreements, executive education, professional and student career development. Based on analysis of globally reviewed successful models, a concept for robust, productive, and extended collaboration between companies and universities is produced suitable for the Finnish context. Several practical experiences are given for robust collaboration in the current post-COVID transition and energy crisis.

**Keywords:** Micro and small-sized enterprises, MSE, Micro, Small and medium-sized enterprises, MSME, SME, University, Collaboration, Cooperation, Success model, Industry–university collaboration, Industrial collaboration, Industrial digitalization, Business collaboration, RDI, Innovation, Strategy, Digital transformation

## Introduction

Building effective and rewarding cooperation between universities and businesses can deliver benefits at the level of individual companies, universities, and industrial networks. Collaboration between companies and universities has a long history involving many different forms of shared activities, knowledge exchange, and co-development models for new technologies, products, processes, business models, brand improvements, company culture (Santti et al., 2017), education enhancement and innovation (Airola et al., 2011; Dhillon et al., 2008; Geiger, 2005; Happonen & Salmela, 2010; Minashkina & Happonen, 2019). Furthermore, cooperation between universities and industries in educational activities improves the quality of graduate training as students are able to apply and link their theoretical knowledge, skills, and abilities with the needs of the labor market (Ornellas et al., 2018; Silva et al., 2018; Stanca et al., 2021). At the same time, such cooperation enhances students' ability to immediately produce value for companies when entering the employment market. As well as motivating students in their studies, university–industry collaboration (UIC) has moreover been found to contribute directly to improved graduate employment rates, which benefits society by reducing unemployment (Klawe, 2019). In addition, the university creates in-demand study programs for current and future company employees, thereby contributing to implementing the principle of lifelong learning (Tran, 2021). The university thus acts as a source of external knowledge and labor, whereas the company in turn is the source, developer, and business transformer for innovation, acting as the pragmatic implementer and commercialization driver of ideas, research, and collaborative development done in the universities (Arvanitis et al., 2008; Hemert et al., 2013). By acting as partners in research and development (R&D) for the creation of innovations and novel solutions (Dhillon et al., 2008; Etzkowitz et al., 2000; Gulbrandsen & Slipersæter, 2007), universities consequently contribute to the growth of innovation and industrial competitiveness in the long term and simultaneously help companies, municipalities, and NGOs find practical solutions to specific short-term challenges (Meerman et al., 2018). Collaboration with research and education units enables business owners to extend their resource utilization rate by enabling research of new business models, promotion of resource utilization reduction opportunities, and development of innovations to solve real-world and vital client challenges. Moreover, the partnership can help to disseminate this new knowledge, including via patents and intellectual property rights agreements, and improve the quality of education and academic work, as well as increase the quantity and quality of scientific publications (Ndou et al., 2011; Perkmann & Walsh, 2007). In turn, the industrial partner can provide universities with financial support, access to specialized equipment, and the expert practical knowledge base necessary for high-quality practice and applied research (Meerman et al., 2018).

### Creating collaborative innovations and new novel solutions

Universities tend to occupy a central place in regional innovation systems (Meerman et al., 2018; Messina et al., 2022) by providing ground-breaking innovations, helping to create spin-off companies and accelerate the creation of startups, and by nurturing new entrepreneurs and helping extend the talents of current entrepreneurs (Dhillon et al.,

2008; Ogunleye, 2007). Thus, university–industry collaboration (UIC) contributes to the creation of new jobs, especially for companies that participate in research, development, and innovation (RDI) activities, thereby boosting local and national economies, stimulating economic growth (Messina et al., 2022; Ogunleye, 2007), and improving living standards (Ndou et al., 2011). Although clearly having much potential, universities, companies, micro, small, and medium-sized enterprises (MSMEs) and regions rarely derive maximum benefit from their interaction, cooperation, and collaboration activities (Marinho et al., 2020; Perkmann et al., 2011). Even when high-level views of collaboration promise many positive outputs, experience has shown that many practical collaboration activities fail sooner or later (Marinho et al., 2020; Yusuf & Nabeshima, 2007).

The potential vs. realization deficiency makes analysis of promising areas of cooperation between universities and businesses and identifying barriers to and incentives for building effective and sustainable interaction a particularly pertinent area of study. It seems that micro, small, and medium-sized enterprises (MSMEs) do not work enough in a comprehensive range to achieve deep innovation collaboration with universities and HEI (Higher Education Institutions), and the level of innovation collaboration formalization (Salmela et al., 2013) especially with micro and small companies, with Higher Educational Institutions, could be heightened. For example, Kayser (2018) analyzed successful and unsuccessful collaboration projects and concluded that successful projects utilized more explicit communication models, set realistic goals, and adopted professional project management practices. Cirella and Murphy (2022) analyzed the role of intermediaries in innovative processes and identified micro-practices for creating and sustaining successful collaboration. Several studies provide strategies and suggestions for successful collaboration and university–industry relations (Chebo & Gebrekidan, 2022; Matheis et al., 2014; Michel, 2014). Pangarso et al. developed a research framework for green economy performance related to MSME readiness related to the green economy and digitalization (Pangarso et al., 2022), which belongs to the highly important set of models, as of the current digitalization of "everything" (Abdelsalam et al., 2022; Moșteanu et al., 2020; Mousavi Baygi et al., 2021; Rad et al., 2020; Widmaier et al., 2013) transition times we live into.

Our work aims to systematically examine successful strategies, models, and core activities in cooperation and collaboration between micro, small, and medium-sized enterprises (MSMEs) and higher educational institutions (HEIs). The goal is to provide a list of potential models for building successful collaboration, comprehensive guidelines for UIC, and guidance for MSMEs and universities to support innovation and growth. The aim is to assist organizations to be able to overcome motivation-related, capability-related, green economy-related and governance-related barriers (Attia, 2015; Muscio & Vallanti, 2014; Nsanzumuhire & Groot, 2020; Pangarso et al., 2022).

The study focuses on micro, small, and medium-sized enterprises (MSMEs) with approximately 249 or fewer employees (OECD Publishing, 2017; SME Definition—European Commission, 2022) and examines collaboration models, activities, and practical implementations in successful cooperation with HEIs that have been shown to provide value for cooperating parties, surrounding regions, and municipal, governmental, or societal entities. In short, the study aims to reveal best practices that can be adapted and applied in industrial enterprises and HEI units worldwide, and to generalize and map the

core elements in a successful UIC relationship. As an additional practical regional goal, the authors reflect on regional and national-based experience with the aim of identifying models suitable for the Finnish context.

The study highlights the current state-of-the-art of UIC in recent literature and proposes recommendations for successful and productive university–industry collaboration. The following section (Sec. II) describes the methodology used in the study. The literature-based findings are then reported in Sec. III. The last section concludes with a synthesized framework or guidelines for successful university–industry collaboration (UIC) and discusses current university–industry models and ways to prolong relationships and collaborations and why universities can act as strategic partners providing novelty-seeking companies with the resources, tools, and knowledge required for innovation and long-term success.

#### Related knowledge on university–industry collaboration

The most well-known models describing interaction between universities, government, and business are the Triple, Quadruple, and Quintuple Helix models of H. Etzkowitz (Cai & Etzkowitz, 2020; Carayannis et al., 2012; Etzkowitz & Leydesdorff, 2000; Leydesdorff & Etzkowitz, 1998) and the Entrepreneurial University model of B. Clark (Clark, 1998; Mitchell, 2012). Despite several conceptual differences, these approaches are united by an understanding of the university as a critical actor in interaction between business and government, and crucial for generating new knowledge, technologies, and forms of entrepreneurship. However, the Triple Helix, Quadruple Helix, and Quintuple Helix are outdated for several reasons: (1) the discrepancy between the speed of change and the flow of knowledge in modern demands; (2) the model's lack of inclusion in digitalization, which complicates the development of UIC. Also, this model does not cover all the necessary areas for full and productive cooperation between universities and other stakeholders to create new knowledge and innovations. The literature highlights positive experiences in innovation, knowledge support, and learning through knowledge networking for MSMEs and HEIs (Cavaliere & Sarti, 2011; Pangarso et al., 2022; Vega et al., 2012). Researchers also note the importance of university activities for developing regional innovation systems and ecosystems (Mercan & Göktaş, 2011; Smorodinskaya et al., 2017; Suominen et al., 2018). In particular, universities are considered as the intellectual core of regional consortia (Arbo & Benneworth, 2007; Bramwell & Wolfe, 2008). In addition, much attention in the literature is paid to study of the peculiarities of specific research universities and the development of their relationships with enterprises (Belso-Martinez et al., 2013; Cirella & Murphy, 2022; Richter & Donnerberg, 2006), as well as analysis of regional and sectoral specifics of entrepreneurship at universities (Caloffi et al., 2015, 2020; Thomas & Maine, 2019).

At the same time, it is noted that there needs to be more synthesis of collaboration between universities and industries, including the need for terminological unity. Some fragmentary empirical materials and cases are available (Cirella & Murphy, 2022; Purnomo et al., 2015; Richter & Donnerberg, 2006; Rodriguez et al., 2013; Wynn & Jones, 2019). In earlier work, researchers have mainly focused on technology transfer issues concerning patents, licenses, and spin-offs without paying due attention to successful and practical models of interaction between universities and enterprises

(Czarnitzki et al., 2012; Grimpe & Hussinger, 2013; Rajalo & Vadi, 2017; Wendji & Pilag Kakeu, 2022). In addition, the main emphasis tends to be on the barriers that hinder UIC, such as a lack of funding, overly bureaucratic structures, lengthy approval processes, etc., and not on the possible drivers of UIC (Attia, 2015; Hilkenmeier et al., 2021; Kleiner-Schaefer & Schaefer, 2022; O'Dwyer et al., 2022; Ruíz-Ruano García et al., 2019). In most studies devoted to the issue of collaboration between universities and industry, only one of the sides of this interaction is considered in detail. Most often, the university's position is based on studies of unique situations of interaction that have developed in specific universities in particular regions. Analysis of relations between universities and industry dyads is still lacking, even though such collaborations are typical drivers of innovations, ideas, and knowledge from both perspectives.

At present, industry faces a shortage of qualified personnel, and there is widespread recognition of the need to train specialists who meet the expectations of the modern workplace (Lucy & Isabella, 2022; Sandborn & Prabhakar, 2015; Shmatko & Volkova, 2020). In particular, companies need people who can retrain quickly and adjust to fast-developing digitalized societies (Tran, 2021). According to the U.S. Chamber of Commerce, the industries with the most job openings are the transportation, health care, social assistance, accommodation, and food sectors (Ferguson, 2023). The Finnish job market is no different; industries with a talent shortage include transportation and logistics (92%), communication services (91%), industry (84%), and healthcare and biosciences (80%) (Skills Shortage in Finland, 2023). Difficulties finding professionals are forcing companies to look for new ways to produce professionals for their needs. It can take months to find suitable employees, and even more time is needed for new employees to adapt to the job, company culture, and processes, and even more time is needed for onboarding (Keller, 2017). Unfortunately, finding an employee does not guarantee that the person stays in the company for the long term as there is always the possibility of someone being headhunted, a non-fit situation with the company, and just a change of heart or life situation. As a result, project deadlines can be shifted, and resources and funds are spent on recruitment and task adaptation. Additionally, CTOs, CEOs, and other company managers will need to spend much of their work time re-scheduling jobs, tasks, work arrangements, and resources and repeating employment and hiring procedures and interviews. In short, intellectual and labor resource challenges hinder MSMEs' performance. Additionally, losing a talented employee means a loss of practical knowledge (Hancock et al., 2013).

Recruitment challenges and labor shortages have led to the creation of new forms of interaction and educational collaboration between academia and industry (Happonen & Minashkina, 2018; Happonen et al., 2020a, 2020b, 2022; Minashkina & Happonen, 2020). The previously mentioned shortage of talented experts has been recognized as a problem at the governmental level. In that context, it is important to note that governments have the resources to open new study programs for professionals in, for example, specific areas like the green transition, digital society platforms, or nuclear science (Salbu et al., 2009). Most companies, particularly MSMEs, do not have the resources to undertake such wide-ranging programs. A common understanding in the industry is that if instead of directly funding and administering a separate program, companies develop collaborative training programs with universities, which necessitates following

the university's targets, regulations, and rules, potential future employees graduating from these programs will have a faster onboarding process, which will save time and resources (Blumberg et al., 2022), as well as improve student employability. In such collaborative programs, project work and industry case studies can form the basis for many courses (Klawe, 2019), and elective courses can be designed based on industry demands and recruitment activities (Jackson & Collings, 2018). UIC-based education can include, for example (Ahmed et al., 2022; Byrne et al., 2014; Cooney & Murray, 2018):

- The creation of programs and departments at universities (de Fátima Cruz et al., 2022; Plewa et al., 2015).
- The opening of company facilities on university campuses (Education Finland, 2023; Intel | Kent State University, 2023).
- The creation of academies and training centers in partnership with universities and industrial partners (Galan-Muros & Davey, 2019).
- The launch of certification courses for specialists and people changing profession (Davey et al., 2011; Galan-Muros & Davey, 2019).
- Short refresher programs enabling managers and leaders to update their skills.

The rationale for researching practices and approaches is to find strong collaboration models. Our work covers the studies that discuss and reveal successful collaboration methods for micro, small- and medium-sized enterprises, and higher educational institutions. The paper addresses common models and activities of university–industry collaboration, providing advice for more robust relations, highlighting the benefits of such partnerships, and describing the activities and operational models utilized.

## Methodology and research materials

A systematic mapping study (SMS) was performed following standard established guidelines and procedures proposed by James et al., (2016) and Petersen et al., (2015). The work utilizes systematic mapping to gain a comprehensive and extensive overview of the study area, ensure an unbiased, fair, and valid assessment of current literature, identify potential research gaps, and collect evidence for near-future development directions (Engström & Runeson, 2011; Kitchenham et al., 2011). This study has the following research goals:

1. Clarification and mapping of the topic in the selected literature.
2. Identification of critical characteristics, key performance factors and current issues.
3. Study of methodologies, models, and activities (designs used, methods, techniques, software, etc.) in the context of successful approaches to industry–university collaboration.
4. Identification and analysis of gaps in existing knowledge to be able to suggest potential areas for further collaboration experiments.
5. Preparation for future follow-up work from a university perspective.
6. Provision of guidelines and recommendations for future collaboration perspectives for practitioners and MSMEs.

Research questions were compiled to narrow the systematic mapping study's focus and direct data collection to the research goal. The objective of this study was to explore and examine successful collaboration strategies, models, and core activities involving micro, small, and medium-sized enterprises (MSMEs) and higher educational institutions (HEIs). Based on these objectives, the following research questions were defined:

- RQ1: What are the current successful collaboration models between micro, small, and medium-sized enterprises, and higher education institutions?
- RQ2: What types of collaboration models of UIC with MSMEs exist and how do they contribute to the research area? What models have already been examined in related literature and how do they contribute to the field?
- RQ3: How can the university and industry sustain long-term relationships for a strong collaboration?
- RQ4: What successful collaboration models exist between MSMEs and higher education institutions?

The authors selected major academic databases according to Gusenbauer (Gusenbauer & Haddaway, 2020; Pangarso et al., 2022) to investigate possible relevant studies. The databases examined were Scopus, WoS (Web of Science), ProQuest, EBSCO, ProQuest Technology, and IEEE. A higher number of databases than typical (3 or 4) was chosen as the study area focuses on overall HEI collaboration between companies, which covers a wide range of application areas. With a broad scope in mind, the goal was to map most, if not all, relevant current successful models, and their core activities by utilizing a wide range of knowledge from a large set of contributing databases. The identified filters utilized were English only, with publication years from 2000 to 2023. We used 2000 as a filter to find all available practices and research, considering that such collaborations only began to take place relatively recently. We also limited the searches to peer-reviewed articles, conference proceedings, books, and book chapters. The search excluded grey literature to focus on peer-reviewed academic content.

#### Data collection phase

Data collection started with the framing of the keyword selection. Several keywords, their combinations, and the value of the results for the study were tested and evaluated. Initial suggestions included "industry-university collaboration", "academic entrepreneurship", "problem-based learning", "technology transfer", and "cooperation approach". Quick skimming of the results and the titles of the studies found showed, however, that the results were quite mixed and included a lot of non-relevant contexts from non-connected topic areas. Using keyword analysis, studies contributing the main keyword groups, discussions with academic professors and companies, and examination of collaboration of authors, further enhancements rounds were made to the keywords to reduce the number of non-fitting results and to widen the scope and contribution of selected studies. A final keyword list was derived for the data collection phase following multiple rounds of the above iteration. The keywords of studies were examined and considered particularly relevant, and their reference lists were

referred to for additional valuable keywords to include in the search phase. The final list of keywords and their Boolean combinations were as follows:

- (Small OR micro OR SME OR"sole proprietor") AND
- (Enterprise OR company OR business OR venture OR organization) AND
- (University OR HEI OR academy OR ("higher educational unit") OR Polytechnics) AND
- (Collaboration OR ("academic engagement") OR ("academic entrepreneurship") OR cooperation OR ("technology-transfer") OR ("university–industry partnership") OR ("university-industry collaboratio*") OR ("university industry collaboratio*") OR ("university-business collaboratio*") OR (" business engagement")) AND
- (success* OR benefi* OR advantag*) AND
- (Framework OR intermediary OR model OR proposa* OR recommendatio*).

As the list shows, the authors divided the keywords into six main groups. The division into multiple search dimensions/keyword groups was needed to be able to focus on relevant studies, remove a wide range of generic MSME and university-related studies, and eliminate non-relevant study streams. Table 1 presents the final keyword groups in their separate group-based columns. Figure 1 presents the number of studies excluded based on the chosen criteria and the final number of primary contributing studies included in the work. The appendix gives information on how the keywords were used for each database (Table 2).

The keywords resulted in 1371 potential studies to evaluate from the six selected databases. The inclusion criteria's included requirement to be written in English and published in 2000 or later. The screening phase removed 640 duplicates, leaving 731 unique search results. These studies were analyzed based on their titles and abstracts, which reduced the number of relevant studies to 112. We then assessed the full text of the papers, which limited the analysis to 93 papers. The exclusion and inclusion criteria included the need to mention UIC in the title explicitly and that the abstract should mention a model, framework, recommendation, or successful collaboration.

**Table 1** Dimension of the keyword

| Collaboration | University | Companies and municipalities | Success | Framework | Company size |
|---|---|---|---|---|---|
| Collaboration<br>Academic engagement<br>Cooperation<br>Technology-transfer<br>University–industry partnership<br>University–industry collaboration<br>University–business collaboration<br>Business engagement | University<br>HEI<br>Higher Education Unit<br>Polytechnics | Company<br>Enterprise<br>Organization<br>Business<br>Venture | Success<br>Advantage<br>Benefit | Framework<br>Intermediary<br>Model<br>Proposal<br>Recommendation | Small micro SME<br>Sole proprietor |

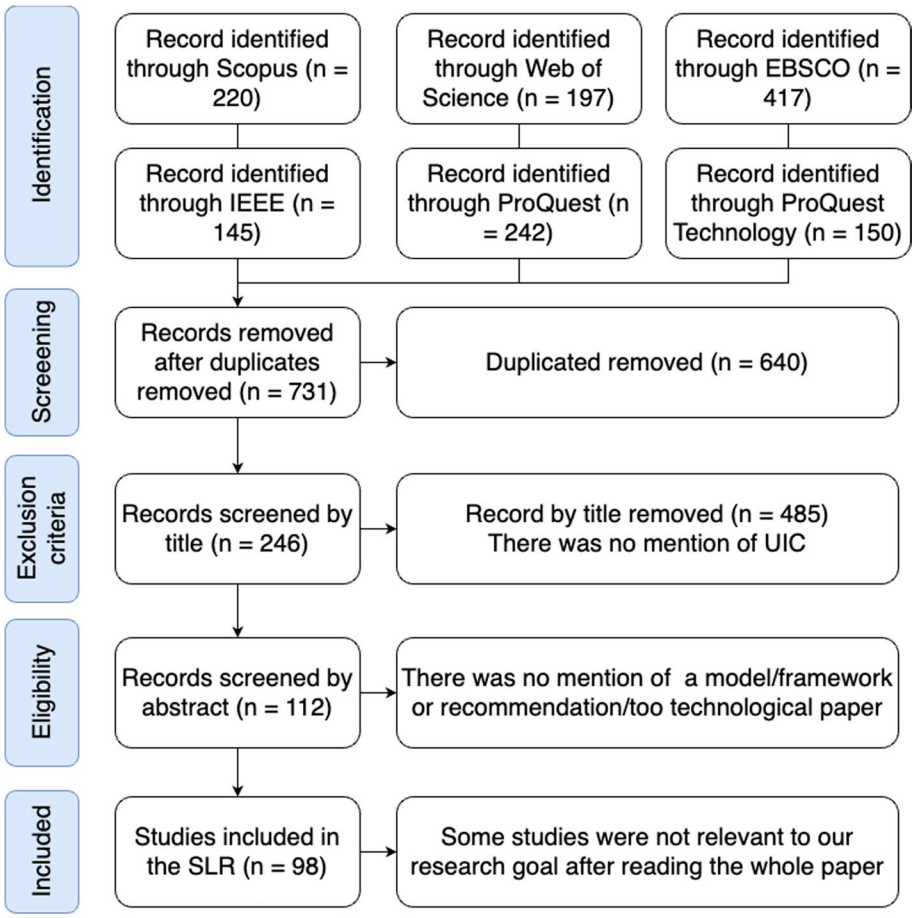


**Fig. 1** Overview flowchart for the systematic mapping study following PRISMA process-related steps (adapted from the Preferred Reporting Items for Systematic Reviews (PRISMA) (Page et al., 2021))

The 93 papers selected were then analyzed for reported joint activities between universities and industries that have been proven to produce particularly relevant results. The authors studied model factors that positively impact successful collaboration between industry and universities, which enabled the synthesis of existing collaborative models for universities and companies. One limitation of this approach might be publication bias. Journals tend to favor articles that report positive results, which leads researchers to present their work in the best possible light.

We categorized the paper based on the year of publication, research methods used, category, type of collaboration, and geographical location of university–industry partnerships. Appendix B, Table 3 lists all 93 selected studies, along with the category and type of collaboration.

## Results

This section synthesizes ideas and suggestions for long-term and productive collaboration between industry and universities. Consideration of a relationship's long-term potential is essential (Padilla-Meléndez et al., 2013). Even though collaboration might start with a small project, workshop, or simple idea, thinking in the long term and being

generous in the relationship are vital ingredients in the recipe for success (Taylor, 2021). The section discusses how to sustain relationships in UIC and presents the identified models from the literature.

### Sustaining long-term relationships in university–industry collaboration

A. Count on a long commitment and stable strategy

From the company's perspective, building long-term relationships with universities, students, and staff is necessary for effective collaboration (Bellini et al., 2019; Padilla-Meléndez et al., 2013). The academic environment operates in set cycles related to study periods, graduation expectations of educational programs, and typical norms in the specific culture and country. This context differs from business life, where the company's needs and business area define the cycle. For successful collaboration, it is assumed that both parties need to be willing to be flexible and be prepared to diverge from their "optimal cycle". Industry and universities should thus clearly understand their aims and expectations (Cirella & Murphy, 2022; Michel, 2014), and a company (MSME and larger enterprise alike) that wants to build a name for itself among partnering universities, starting with first-year students, must create stable and long-term relationships with selected HEIs and try to work on a long-term basis.

B. Personal level and relationships are most important

Building relationships is an essential step in successful long-term UIC. Understanding how companies' and universities' goals can be aligned and synchronized and how both parties can find synergy benefits helps to create a clear strategic collaboration vision. So, finding similarities in missions and strategies and valuing shared trust (Bellini et al., 2019; Happonen & Siljander, 2020) in relationships with acknowledgments of each other's competencies will improve company and university relations (Cirella & Murphy, 2022). If a company and university truly value collaboration, it should be shown, e.g., by congratulations on anniversaries and other small and big tokens of gratitude to help people and companies grow closer. Closer relationships help form and maintain the implementation of shared goals and projects and improve understanding of the resources needed to achieve the shared goals (Michel, 2014; Padilla-Meléndez et al., 2013).

C. The more public communication and visibility, the better

The importance of networking and a wide range of strong and weak contacts is widely acknowledged in the business community (Matheis et al., 2014). All forms of communication, like letters, calls, meetings, and messages in communication applications and social networks can be used to maintain networks. Additionally, participation and speaking at forums and conferences attended by potential partners can benefit the brand and enhance general visibility. However, it is also important to invite network partners, too. For example, management of HEIs, teachers, researchers, company collaboration coordinators, and students can be invited to local and

national events involving the MSME. Another easy form of collaboration is to write shared opinion papers, reports, social media blogs/expressions of development needs, articles, comments, and columns in academic, professional, and general media.

Collaboratively joining various working groups and advisory bodies and combined participation at conferences, seminars, symposiums, and hackathons are other ways to improve visibility. Within the university environment, MSMEs can speak at HEI open days, freshman days, job fairs, industrial product/service release events, local technology fairs, etc. The company can also organize excursions to their production sites and offices and arrange open day events to test their solutions and products with the option to discuss with product developers, sales managers, and customer relationship personnel. Key aspects in the selection of communication channels are the shared goals set, the market sector of the MSME, the strategy and vision for the collaboration, and the partners involved (Padilla-Meléndez et al., 2013).

D. Individual approach

Most universities and companies aim to emphasize their uniqueness, highlighting differentiation from competitors and focusing on the unique benefits (Ramdan et al., 2021) potentially available from cooperation and collaboration. In a highly competitive world, it is logical to pinpoint the special value offered to potential partners. Therefore, customization of collaboration activities, and products is vital for successful UIC.

E. Special shared projects for win–win results

Digitalization has made the world more globalized, smaller, and highly connected (Schneider & Kokshagina, 2021). As a result, most of the modern tangible assets tend to include some form of electronics and run software (execute program code), making things more complex, complicated, and harder to fix compared to pre-2000s. At the same time, smartphones and gadgets, Industry 4.0 solutions, electronification, and digitalized societies are steering educational activities toward quick development or change cycles (Schneider & Kokshagina, 2021). To date, it is evident that traditional teaching formats are losing their student audiences' interest, and a transition from on-class teaching towards online and hybrid events is undergoing, advanced especially by the Covid-19 pandemic (Pokhrel & Chhetri, 2021). This transition is working to the benefit of MSMEs as digitalization makes it more efficient, faster, and less resource-demanding to participate in university–industry collaboration.

On the other hand, the transition means that MSMEs must become familiar with online collaboration approaches, which could give a significant benefit to those companies whose employees possess this specific skill set, or younger personnel who have become accustomed to digital learning through their own study path and life experience. On the practical side, activities like online courses and lectures, TED-style speeches, interactive job fairs, and virtual reality (VR) or augmented reality (AR) technologies in the classroom and metaverse environment are already becoming more commonplace, and teachers are building the required skillset and universities

are acquiring the necessary tools. Consequently, HEI audiences are reasonably well prepared for this sort of collaboration form (Hung et al., 2017; Pokhrel & Chhetri, 2021; Sommerauer & Müller, 2018). Therefore, industries' creative online participation modes are also highly welcomed in the UIC context.

#### Current collaboration models from the literature

Next, we will consider current collaboration models involving MSMEs and higher educational institutions that are reported in the literature (Belso-Martinez et al., 2013; Caloffi et al., 2015; Cirella & Murphy, 2022; Duzdar et al., 2015; Feldmann, 2014). Such models are typically divided and structured into three thematic areas: education, research, and management (Galán-Muros & Plewa, 2016). Research is related to conducting joint research; education aims to provide educational services on a short-term or long-term basis, and management aims at joint strategic and technological development. Implementing all these parts is optional for a successful collaboration model; however, combining them can strengthen long-term UIC relations tremendously.

The most typical form of UIC is linked to educational activities (D'Este & Patel, 2007; Perkmann & Walsh, 2007). This activity involves different types of interaction between universities and industry regarding the training of students, educating company personnel on courses similar to those done by full-time students, and offering certification and re-training activities for company employees. In practice, implementations include, e.g., the following types of activities:

1. Joint development of curricula. Companies participate in creating and modifying curricula, modules, and disciplines, as well as supporting and modifying the specific set and content of courses within the boundaries of educational standards (Lange et al., 2006; Maghiar, 2014; Pachura & Nitkiewicz, 2020).
2. Joint lecturing and guidance in the production of final theses and papers. This collaborative activity between universities and companies is widespread (Lange et al., 2006; Lutenberg, 2020).
3. Mobility of students within the framework of industrial practice or collaboration projects between business and university. Students are attracted to participate in consulting projects on a paid basis involving experienced experts or alternatively on a volunteer basis. Students receive valuable practical experience, and companies receive free labor. However, unpaid internships have been seen to have significant weaknesses, leading to job dissatisfaction and poor career opportunities (Rogers et al., 2021; Sanger et al., 2006; Tepper & Holt, 2015; Zilvinskis et al., 2020).
4. Development of dual training programs. Such programs combine theoretical training at the university and practical classes at companies (Green, 2010; Jubinville & Lynch, 2017; Salbu et al., 2009; Schmidt & Mosgaard, 2020; Wang et al., 2009).
5. Companies and universities co-offer special courses like hackathons and code camps to train students on modern technologies and to give them a chance to solve challenges typical for companies in their business actions (Happonen & Minashkina, 2018; Happonen et al., 2020a, 2022).

6. Mentor training in leadership, and course visits from experienced graduates who know the academic unit's traditions and can guide students towards successful career paths. Company representatives can get to know the thinking of younger generations and their future hopes, visions, and goals (Becker et al., 2010; Stanfill et al., 2010).

The second theme of interaction between universities and business—collaboration in research activities—unites such types of joint activities of higher education units and companies:

1. Conducting joint R&D, including agreements on cooperation between universities and businesses to implement joint research activities, regardless of the funding source (Grimpe et al., 2021).
2. Consulting activities in which universities solve specific short- and medium-term problems of commercial companies (Wood et al., 2015).
3. Staff mobility, i.e., the temporary labor movement between universities and enterprises to implement various projects. Within the framework of a mobility program, business specialists are involved in university research activities, and university employees can work in the company sector for several years while continuing to adhere to their chosen professional trajectory (Arquilla et al., 2011; Eseonu & Wyrick, 2010).
4. Collaborative networked RDI programs and long-term structures where multiple network partners, formed by one or multiple research units and companies, tackle complex development challenges together (Bialek-Jaworska & Gabryelczyk, 2016; Siivonen et al., 2022).

The third theme of joint activity of universities and companies is collaboration in management. This collaboration reflects the strategic nature of cooperation between universities and businesses. Among the most significant types of collaboration, we would like to highlight the following:

1. Participation in management activities. Membership of university representatives on the boards of directors of enterprises, and vice versa, and the inclusion of business representatives on the boards of trustees of universities.
2. Sharing resources, such as infrastructure and personnel (Amano-Ito, 2020; Arquilla et al., 2011; Yi & Zhang, 2022).
3. Support from companies such as donations, sponsorship, and scholarship programs for teachers and students.
4. Promoting academic and student entrepreneurship, for example, creating spin-off companies by university teachers or students (Calvo et al., 2012; Green, 2010; Wang et al., 2009). At the same time, legislation that limits the ability of professors to create their businesses must be considered. That is why university employees usually participate only in R&D and licensing.
5. Startups, intellectual property, and patent creation (Aksoy & Beaudry, 2021; Brem et al., 2017; Messina et al., 2022; Thomas & Maine, 2019)

Because of the limitations on university employees, the creation of startups by students is much more common. These activities require long-term cooperation between universities and industry, high shared trust (Bellini et al., 2019; Happonen & Siljander, 2020), and transparency. The above list gives the most common ways in which universities and businesses can collaborate to drive innovation, enhance skills and expertise, and foster economic growth. The summary of the most common strategies for UIC is presented in Fig. 2.

University–industry collaboration does not happen in a vacuum; there is always some underlying reason, perceived benefit, and motivation. The motivation for collaboration may be a concrete goal or the wish to work for the greater good of society. According to survey research by Elsevier (Taylor, 2021), academic units and universities have a least five drivers to collaborate with industries: (1) better potential for societal impact; (2)

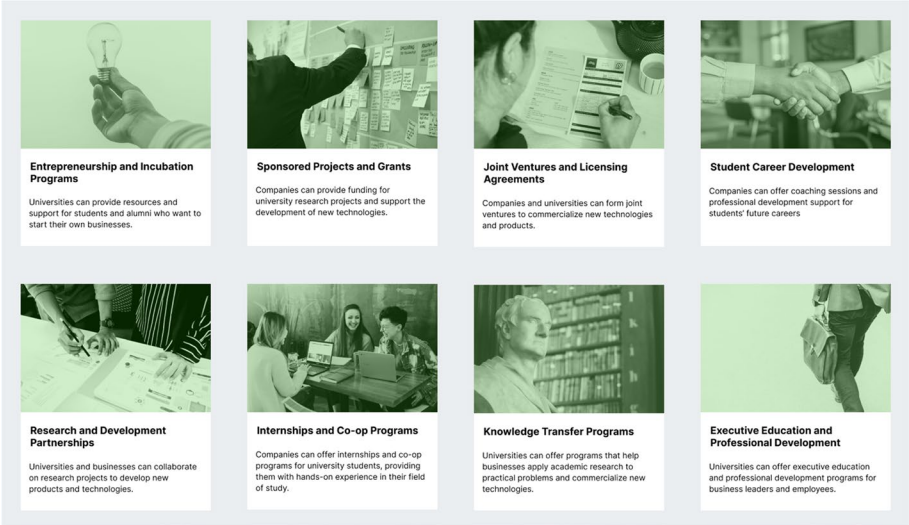


**Fig. 2** Strategies for university–industry collaboration (photos are taken from Unsplash)

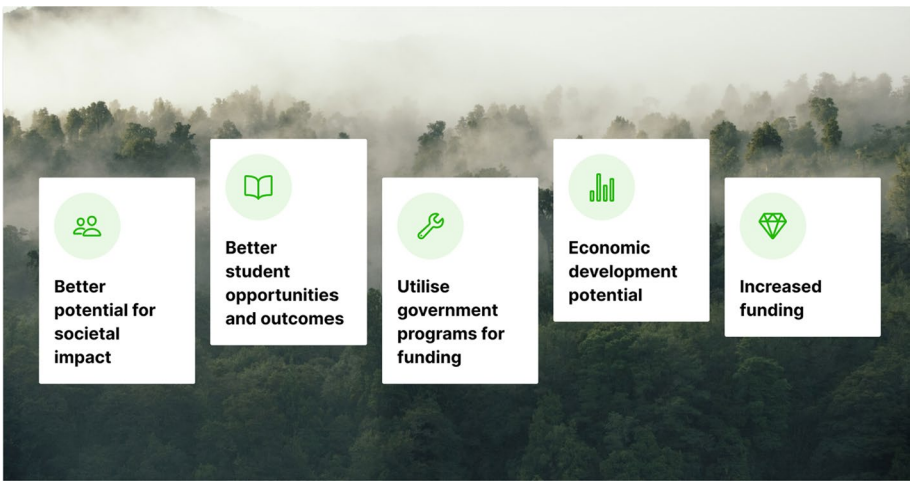


**Fig. 3** University value for collaborating with the industry (Elsevier, 2021)

better student opportunities and outcomes; (3) increased funding; (4) economic development potential; and (5) utilization of government programs for funding (Elsevier, 2021). These five most often cited benefits are illustrated in Fig. 3. In the following, we will focus on practice-based experiences for different possibilities to improve, enhance, and find new levels of productive collaboration between higher education units and industry.

## Practice-based views on key success elements in UIC activities

The following recommendations are based on extended collaboration between personnel in HEI units and their industrial, municipal, city, and company-level collaboration partners. The recommendation has been built from the point of view of offering practitioners more realistic touch points toward UIC collaboration to understand how academics, teachers, managers, and other representatives on the HEI side might see the collaboration. Information from the section should provide municipal leaders, decision-makers, and MSME support organizations with new insights and offer new opportunities to widen collaboration with HEIs and companies. The ideas were framed, developed, and tested by utilizing all the authors' rich experience collaborating with various national and international network partners, stakeholders in different municipalities, NGOs, and private companies. The authors especially provide experiences and insights from Finnish industry companies' collaboration with universities; however, the location does not affect that much to the results, as many of these companies work in international markets, in most of the developed countries, the overall (capitalism) based markets tend to work self similarly and activities were idea tested with international collaborators. Future research is suggested to focus on providing a more profound and extensive study of countries of different socio-economic statuses and cultural environments, such as Asian and African market areas.

Suppose a person from a municipal/city or company environment wants to collaborate with the university. In that case, the best thing they can do is self-reflect on what they need/want/are willing to seek out with their considered university partner. For example, the first thing to consider is expected results and base assumptions for working and communicating. Remember, approachability, ease of contact, visibility, and accessibility are essential for a good partnership. Usually, collaborators are expected to put time and effort into this collaboration. It is worth asking and placing your and your collaborators' operational, tactical, and strategic goals on paper. Then, note the concrete outcomes everyone involved expects to receive and any potential partner-specific goal expectations. In the case of a long-term partnership, a long-term vision should also be reflected, discussed, and put on paper.

The second recommendation is to have an open mind on questions, ideas, and inputs from outside of your own inter-company and close networks. When building and upkeeping UIC, remember that people tend to have different backgrounds, and sometimes, "new ideas" on their minds are old news for you. But do also remember that, e.g., technology develops so fast that an idea "old already five years ago" might have a new twist nowadays, and you should always ask for more details, such as what the implementation concept the idea giving person had in mind. Try to fight against "not invented

here" personal/organizational culture as much as possible, as it is just a waste of energy and reduces the chance of being part of creating something genius, new, and novel. Trust-based, non-paper written, and "gentlemen's agreement" like atmosphere tends to be the most productive environment for flourishing collaboration.

On the side of higher education units, people should keep track of total and currently available collaboration resources. In addition to resources in general, it would be essential to estimate resource needs in different phases of collaboration, from start to finish, to avoid huge spikes and overloads in time and other resource needs. Everyone at UIC should speak up about potential "no time for anything" resource issues as soon as possible. Re-scheduling is many times an option if time is given for it. Some HEI personnel have spoken that companies are not active enough on collaboration interfaces, like shared planning of student thesis works, shared projects, and similar seed-like operations for larger-scale collaboration and innovation discussion tasks. Still, this activity tends to be a self-improving loop.

Agree and discuss daily routines, expected "I call/respond you back", delays, and contractibility expectations. It is acceptable that some/all the partners in the collaboration network have a working time frame from 8 AM to 4 PM if agreed—no contacts on weekends or holidays. But also remember to reflect this to the set goals, timetable, and response time you expect from others. Could it be possible to relax typical accessibility rules or agree on weekly meetings to some "nontypical time", like Saturday 10 AM for 30 min for weekly updates? If the collaboration is set up for fast results needs, and everyone is busy in their daily routines, some out-of-the-box thinking might be needed to go around the "weekly hours" limitation. If you work in an industry environment and you have good working reporting standards, which save a lot of your own time (e.g., Every X Day, by Y time a maximum of half page long report of progress in agreed things and planned next steps"), teach the process and template for your new HEI collaborators. Small investment in "industry efficiency", should payback as a significant save on time later.

Organizational cultural disparities, conflicting priorities, and intellectual property rights management can easily pose significant obstacles to successful collaboration, especially if no agreed-upon trust level fits gain-and-pain-sharing models (Happonen & Siljander, 2020) for the benefits the collaboration can bring to the table. Establishing a culture of trust and fostering effective communication channels are crucial steps in addressing previously mentioned obstacles. Encouraging interdisciplinary collaboration and aligning long-term strategic goals is known to offer good ground for enhancing the effectiveness of collaboration models, facilitating a more seamless and productive relationship between industry and academia (Cirella & Murphy, 2022). Therefore, the summary of recommendations:

1. Approachability, ease of contact, visibility, and accessibility are essential for a good partnership (Bellini et al., 2019; Padilla-Meléndez et al., 2013).
2. Have an open mind on questions, ideas, and inputs from outside intercompany and close networks (Matheis et al., 2014).

3. Estimate resource needs in different phases of collaboration, from start to finish, to avoid time overload and other resource needs. This iteration can be made several times if needed (Michel, 2014).
4. Weekly team stand-ups and clear communication will speed up achieving the goals (Cirella & Murphy, 2022; Michel, 2014).

We have reflected on regional and national-based collaboration experiences and what affects communication and collaboration results. From the practical 25 years of experience of the authors at UIC, we have identified some models suitable for the Finnish context. The presented examples of interaction formats are relevant, and many such formats are used in practice in Finland—for example, project-based courses, hackathons (Happonen & Minashkina, 2018; Happonen et al., 2020a, 2020b), paid master thesis positions, joint research projects, collaborative order research, etc. (Airaskorpi, 2023). Micro and small enterprises predominate in Finland (Kotavaara, 2022; OECD, 2022), so interaction with the university can help to obtain additional funding or the necessary resources. At the same time, the Finnish market has its population-based limits and, as such, might not cover all the needs of universities. In the time of digitalization and online global collaboration, distance, resources, and networks do not limit innovations in the way they did in history. Therefore, considering the digital environment, we have tried to see how the current theories and models can be reproduced in Finland. Before, innovations were born in concentrated areas such as Silicon Valley, Kendall Square in Cambridge, Massachusetts, and Block 71 in Singapore, representing an "innovation ecosystem" (Schiuma & Carlucci, 2018). However, during the globalization of business, the innovation ecosystem is no longer limited to one region, specific socio-economic group, or industry. On the contrary, the most effective innovation ecosystems often combine diverse and complementary capabilities worldwide (Kolk et al., 2018) and are present in online or even metaverse environments nowadays. In other words, a key factor in collaboration is an opportunity to integrate into the digital world and digitalize and utilize digitalization (Adomako & Nguyen, 2023). Including digitalization into the models as an environment complements these models, making them more focused on modern challenges and integrated into the digital space (Happonen et al., 2020b).

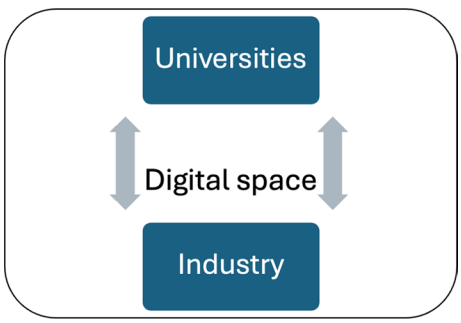


**Fig. 4** Visualized collaboration model for Finnish context

Digitalization in the Finnish context helps to widen activities and not limit them to location. Some examples of digital collaboration include joint educational programs with industries, collaborations with foreign universities, virtual incubators, and jointly created virtual research centers. The visualized relation UIC model is presented in Fig. 4.

Recommendations were generated for the first steps and introduction phase of new collaboration models between (Finnish) MSMEs and higher education units like universities. The use of modern digital technologies in interaction with industry is a fundamental factor of effective interaction (Happonen et al., 2020b; Van Den Berg, 2019). The universities and industry's openness and proactivity are key components of successful collaboration and achievement of the set goals. The research and development of the current best-fitting model is only at the initial stage and requires testing in future university activities.

## Discussion and summary

The conducted research confirms the importance of adopting a broad approach to the interpretation of cooperation between universities and enterprises: collaboration between universities and businesses should be considered as a process of long-term mutually beneficial relations with a wide range of possible types of actors, which may also include government, non-profit and public organizations. Ultimately, it is not a set of isolated actions within a limited range of interaction. In addition to the formal collaboration activities discussed in the article, it is also necessary to consider a wide range of informal contacts between university employees and commercial firms. Participation in conferences and job fairs, coaching consultations, working group meetings at enterprises, and personal contacts contribute to strengthening ties between universities and businesses, although such connections are difficult to quantify. Sometimes, existing personal contacts of university staff play a critical role in fostering collaboration with commercial enterprises, and the ability to adapt to a changing world, both in physical and virtual environments, will be a needed skill for all successful UIC partners.

Our work shows that cooperating with industries in one area, for example, in the field of R&D, can enhance the potential for cooperation in other areas, too. For instance, a researcher may invite a participant in R&D UIC to give a guest lecture, which can help students become aware of modern business operations or technologies. Moreover, it should be borne in mind that scientists' lack of direct interaction with businesses does not mean they would not or do not want to cooperate with organizations outside higher education. For example, HEI employees not collaborating with commercial companies could be working with government or municipal organizations, other public organizations, NGOs, or a colleague from an overseas HEI (Abramo et al., 2011; Bozeman et al., 2013; Iglič et al., 2017). In this regard, a comprehensive and wide-ranging approach to the interpretation of cooperation between universities and businesses is becoming increasingly relevant, allowing for the strengthening of trust between the parties in a partnership, simplifying the organizational side of the interaction, and serving as the basis for the development of a system of indicators for evaluating the effectiveness of collaboration between universities and industry. Based on current findings, the literature does mention cultural (Bertello et al., 2022), gender (Verdugo-Castro et al., 2022),

and socio-economic differences as potential roadblocks to successful collaboration and collaborative boosting of the ongoing digital revolution. Also, in addition to roadblocks in the university–industry collaboration sectors, challenges in internal student group collaboration matters (Lailiyah et al., 2021) should also be taken into account, as these groups can easily be part of university–industry collaboration in the wider picture. In short (Helbing & Hausladen, 2021), there is clearly space for more, deeper, and widely extended studies to clarify ways to open those roadblocks and go forward with shared goals, including technology-enhanced and connected sustainability-advancing solutions. For example, hackathons and Code camps were mentioned in multiple contexts as one of the natural tools to enhance industry collaboration for HEIs, but very little was talked about, e.g., participating students' gender roles (Kovaleva et al., 2024) and inclusiveness in this context. This would be an important area to extend research, as ICT and software engineering are male dominated now, and all genders use the results, products, and solutions equally.

## Conclusion and future research

Interaction between higher education institutions (HEIs) and enterprises, corporations, companies, or businesses is becoming increasingly important but may also, at some level, be becoming more challenging, especially in the current conditions of a dynamically developing knowledge-oriented economy. In this work, we discussed the benefits of university–industry collaboration (UIC), potential actions to ease the start of collaboration, and ways to enhance positive outcomes and maximize success in UIC. For HEIs, there is potential for extra funding for students, improved opportunities for future career paths and skills development, and potential positive social impact, both locally and nationally. Involving representatives of businesses in education activities and addressing real-world challenges allows universities to consider current trends in entrepreneurship development and adjust the trajectory of students' education to consider business needs more closely. At the same time, students will learn what is currently happening in companies, what sort of challenges companies work with, and why. As a result of practical interaction with micro, small, and medium-sized businesses, students will be able to master modern methods and tools for planning and analyzing entrepreneurial activity, which will allow the successful implementation of business ideas in practice, promote the creation of business startups, and improve students' ability to undertake managerial work. However, cooperation is also beneficial for companies. It provides access to new scientific knowledge, allows companies to access the international academic experience of research scientists, and is an opportunity to involve highly qualified specialists in internal tasks. Moreover, cooperation makes it possible to implement a practice-oriented approach in training and forming professional skills and abilities among graduates based on solving the real needs of micro, small, and medium-sized businesses.

This study identified and discussed current models of successful collaboration between micro, small- and medium-sized enterprises, and higher education institutions. We used a three-part division of university–industry collaboration (UIC) activities: education, research, and management. The education aspect comprises

all types of interaction between universities and industries in student education and training of company employees. The research component unites research collaboration activities of universities and companies, such as conducting joint R&D, innovation activity, or consulting services. Management reflects the strategic nature of collaboration between universities and businesses. In the work, we provided eight successful collaboration models: Research and Development Partnerships, Internships and Co-op Programs, Knowledge Transfer Programs, Entrepreneurship and Incubation Programs, Sponsored Projects and Grants, Joint Ventures and Licensing Agreements, Executive Education and Professional Development, and Student Career Development. Each model or type of collaboration can be combined or used separately for more robust and extended relationships between universities and industry. Additionally, we put the literature and experience-based findings into the frame of recommendations and key points beneficial for those studying UIC or seeking to develop UIC. We enhance the concept of Quintuple Helix theory by adding a digital environment as a foundation for the innovations and creation of new knowledge in collaborations.

Analysis of the collaboration experience is crucial, as it shows promising areas for developing cooperation with micro, small, and medium-sized enterprises. Based on the data obtained, the following suggestions for the development of the relations between universities and businesses are made:

- Attract businesses to develop programs and courses jointly.
- Provide company employees with crash courses about new technologies and new trends.
- Develop educational activities and training for the adult population.
- Share resources, such as infrastructure and personnel or knowledge.
- Participate in management meetings for a clear vision and mission.

A positive result of UIC is that joint efforts in implementing the study's subject area may, in the long term, increase the quality of labor resources, labor productivity, and the competitiveness of participating universities and companies in world markets.

Although some of the findings may, on the surface at least, appear self-evident, the novel contributions of this study lie in its analysis and synthesis of successful collaboration models, which are divided into three parts: education, research, and management. Moreover, practical implications are ideas and tips for a more long-term and active collaboration between industry and university. To continue developing knowledge and experience of university–industry collaboration, we suggest focusing on collaboration involving a particular industry sector or university subject area. Future research topics could include whether faculty should be active in company relations or whether universities should have a collaboration unit responsible for establishing connections and searching for possible partnerships. In future research, we plan to build tests for collaboration models in our university and validate them and their value in the Finnish context.

# Appendices

## Appendix A

See (Table 2).

**Table 2** Database search strings and search field

| Database | Search field | Keyword string |
|---|---|---|
| Scopus | TITLE-ABS-KEY | TITLE-ABS-KEY ((small OR micro OR sme OR "sole proprietor") AND (enterprise OR company OR business OR venture OR organization) AND (university OR hei OR academy OR ("higher educational unit") OR polytechnics) AND (collaboration OR ("academic engagement") OR ("academic entrepreneurship") OR cooperation OR ("technology-transfer") OR ("university–industry partnership") OR ("university-industry collaboratio*") OR ("university industry collaboratio*") OR ("university-business collaboratio*") OR (" business engagement")) AND (success* OR benefi* OR advantag*) AND (framework OR intermediary OR model OR proposa* OR recommendatio*)) |
| IEEE | All Metadata | ("All Metadata":Small OR "All Metadata":micro OR "All Metadata":SME OR "All Metadata":"sole proprietor") AND ("All Metadata":enterprise OR "All Metadata":company OR "All Metadata":business OR "All Metadata":venture OR "All Metadata": organization) AND ("All Metadata":university OR "All Metadata":HEI OR "All Metadata":academy OR "All Metadata":"higher educational unit" OR "All Metadata":Polytechnics) AND ("All Metadata":collaboration OR "All Metadata":"academic engagement" OR "All Metadata":"academic entrepreneurship" OR "All Metadata":cooperation OR "All Metadata":"technology-transfer" OR "All Metadata":partnership OR "All Metadata":"university-industry collaborations" OR "All Metadata":"university-business collaborations") AND ("All Metadata":success* OR "All Metadata":benefi* OR "All Metadata":advantag*) AND ("All Metadata":framework OR "All Metadata":intermediary OR "All Metadata":model OR "All Metadata":proposa* "All Metadata":recommendatio*) |
| ProQuest | TITLE-ABS-KEY | TI,AB,IF((Small OR micro OR SME or "sole proprietor")) AND TI,AB,IF((enterprise OR company OR business OR venture OR organization)) AND TI,AB,IF((university or HEI OR academy OR ("higher educational unit") OR Polytechnics)) AND TI,AB,IF((collaboration OR ("academic engagement") OR ("academic entrepreneurship") OR cooperation OR ("technology-transfer") OR partnership OR ("university-industry collaborations") OR ("university-business collaborations"))) AND TI,AB,IF((success* OR benefi* OR advantag*)) AND TI,AB,IF((framework OR intermediary OR model OR proposa* or recommendatio*)) |
| Web of Science | Topic | ((small OR micro OR sme OR "sole proprietor") AND (enterprise OR company OR business OR venture OR organization) AND (university OR hei OR academy OR ("higher educational unit") OR polytechnics) AND (collaboration OR ("academic engagement") OR ("academic entrepreneurship") OR cooperation OR ("technology-transfer") OR ( "university–industry partnership") OR ( "university-industry collaboratio*") OR ("university industry collaboratio*") OR ("university-business collaboratio*") OR (" business engagement")) AND (success* OR benefi* OR advantag*) AND (framework OR intermediary OR model OR proposa* OR recommendatio*)) |

**Table 2** (continued)

| Database | Search field | Keyword string |
|---|---|---|
| EBSCO | Title, abstract, author-specified keywords | Title:((Small OR micro OR SME or "sole proprietor") AND (enterprise OR company OR business OR venture OR organization) AND (university or HEI OR academy OR ("higher educational unit") OR Polytechnics) AND (collaboration OR ("academic engagement") OR ("academic entrepreneurship") OR cooperation OR ("technology-transfer") OR partnership OR ("university-industry collaborations") OR ("university-business collaborations")) AND (success* OR benefi* OR advantag*) AND (framework OR intermediary OR model OR proposa* or recommendatio*)) AND Abstract:((Small OR micro OR SME or "sole proprietor") AND (enterprise OR company OR business OR venture OR organization) AND (university or HEI OR academy OR ("higher educational unit") OR Polytechnics) AND (collaboration OR ("academic engagement") OR ("academic entrepreneurship") OR cooperation OR ("technology-transfer") OR partnership OR ("university-industry collaborations") OR ("university-business collaborations")) AND (success* OR benefi* OR advantag*) AND (framework OR intermediary OR model OR proposa* or recommendatio*)) AND keyword:((Small OR micro OR SME or "sole proprietor") AND (enterprise OR company OR business OR venture OR organization) AND (university or HEI OR academy OR ("higher educational unit") OR Polytechnics) AND (collaboration OR ("academic engagement") OR ("academic entrepreneurship") OR cooperation OR ("technology-transfer") OR partnership OR ("university-industry collaborations") OR ("university-business collaborations")) AND (success* OR benefi* OR advantag*) AND (framework OR intermediary OR model OR proposa* or recommendatio*)) |
| ProQuest Technology | TITLE-ABS-KEY | TI,AB,IF((Small OR micro OR SME or "sole proprietor")) AND TI,AB,IF((enterprise OR company OR business OR venture OR organization)) AND TI,AB,IF((university or HEI OR academy OR ("higher educational unit") OR Polytechnics)) AND TI,AB,IF(((collaboration OR ("academic engagement") OR ("academic entrepreneurship") OR cooperation OR ("technology-transfer") OR partnership OR ("university-industry collaborations") OR ("university-business collaborations"))) AND TI,AB,IF((success* OR benefi* OR advantag*)) AND TI,AB,IF((framework OR intermediary OR model OR proposa* or recommendatio*)) |
| Year filter | Publication year | 2000–2023 |
| Type filter | Document type | Articles, conference papers, books, book chapter |
| Language filter | Language | English |

## Appendix B

See Table 3.

**Table 3** Information about selected 93 papers for the research

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Cirella, S.; Murphy, S. 2022 | Identifying what people do when initiating and maintaining innovative projects based on U-I collaboration and exploring intermediary roles in UIC | Conducting joint R&D | Research | Qualitative research | Italy |
| Messina, L.; Miller, K.; Galbraith, B.; Hewitt-Dundas, N. 2022 | Show how spin-offs develop adaptive, absorptive, and innovative capabilities to overcome formation's critical junctures successfully | Startups, intellectual property, and patent creation | Management | Qualitative research | Not mentioned |
| Aksoy, A.Y.; Beaudry, C. 2021 | Contribute to the discussion on license payment schemes and shed light on the different payment schemes companies and universities adopt when transferring university-sourced technologies | Startups, intellectual property, and patent creation | Management | Mixed | Canada |
| Foray, D.; Woerter, M. 2021 | Investigate the meaning of Coasean institutions in Switzerland for the innovation performance of firms | Conducting joint R&D | Research | Mixed | Switzerland |
| Jun, S.-P.; Yoo, H.S.; Hwang, J. 2021 | Develop a method of recommending types of external collaboration organizations that are optimal partners for SMEs | Conducting joint R&D | Research | Mixed | South Korea |
| Lu, C.; Yu, B. 2021 | Investigate the relationships between two types of external collaboration in UIC and the innovation performance of SMEs in the Chinese context | Sharing resources, such as infrastructure and personnel | Management | Mixed | China |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Happonen, A.; Santti, U.; Auvinen, H.; Räsänen, T.; Eskelinen, T. 2020 | Investigate a digitalization-related business model because of the university–SME collaboration | Hackathons | Education | Mixed | Finland |
| Lutenberg, A. 2020 | Share experience about collaboration experience industry cases | Joint lecturing and guidance in the production of final theses and papers | Education | Qualitative research | Argentina |
| Darabi, F.; Saunders, M.N.K.; Clark, M. 2020 | Explore trust initiation and development in collaborations between universities and small- and medium-sized enterprises | Conducting joint R&D, Grants | Research, Management | Qualitative research | The UK |
| Pachura, A.; Nitkiewicz, T. 2020 | Share experiences in building collaboration between university and social enterprises about creating courses | Joint development of curricula and courses | Education | Not mentioned | Poland |
| Amano-Ito, Y. 2020 | Sharing experiences about Medical Device Development through Industry–Academia Collaboration | Sharing resources, such as infrastructure and personnel | Management | Not mentioned | Japan |
| Schmidt, K.; Mosgaard, M.A. 2020 | Share experience about building a course and learning program | Development of dual training programs | Education | Qualitative research | Denmark |
| White, G.R.T.; Cicmil, S.; Upadhyay, A.; Subramanian, N.; Kumar, V.; Dwivedi, A. 2019 | Explore the soft side of knowledge transfer partnerships between universities and small to medium enterprises (SMEs) | Technology Transfer, intellectual property, spin-offs | Management | Mixed | The UK |
| Pinilla, L.S.; Rodríguez, R.L.; Gandarias, N.T.; de Lacalle, L.N.L.; Farokhad, M.R. 2019 | A new way to create new advanced manufacturing centers is presented, centers whose activities are focused on Technology Readiness Levels | Technology Transfer, intellectual property, spin-offs | Management | Mixed | Spain |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Reid, R.; Rising, E.; Kaufman, A.; Bassett, A.; McGrew, M.C.; Silverblatt, H.; Haederle, M. 2019 | Share how to engage both the University and local partners in ways that allow for an entirely new approach to recruiting, supporting, and retaining local healthcare professionals effectively | Sharing resources, such as infrastructure and personnel | Management | Not mentioned | The USA |
| Betts, S.C.; Santoro, M.D. 2019 | Offer a model for the development of engaged and entrepreneurial relationships from the university's perspective | Joint development of curricula and courses | Education | Not mentioned | The USA |
| Morel, L.; Camargo, M.; Lhoste, P. 2019 | Not available | Not available | Not available | Not available | Not available |
| Winkelmann, A.; Schendzielorz, J.; Maske, D.; Arends, P.; Bohne, C.; Hölzer, H.; Harre, K.; Nübel, J.; Otto, B.; Oess, S. 2019 | This master plan provides for reforms, for increasing relevancy to practice, improving the links between preclinical and clinical curricular content, and strengthening general practice and competencies revolving around communication, interpersonal skills, and academic scholarship | Development of dual training programs | Education | Not mentioned | Germany |
| Van Den Berg, C. 2019 | Presents a case study of a project that was collaboratively developed between industry and academia using a design-based research (DBR) approach in a mixed-methods design | Collaborative networked RDI programs and long-term structures | Research | Mixed | South Africa |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Gudele, I. 2019 | This article analyzes the usage of the Helix models for the development of innovative services in one project in Latvia, where the successful cooperation between two universities from Latvia and Lithuania, a small innovative enterprise, local and national media, a municipal organization, and a professional nongovernmental organization, brought about excellent results | Conducting joint R&D | Research | Qualitative research | Latvia and Lithuania |
| Wynn, M.G. 2018 | Examines how technology transfer has operated in university–company projects undertaken in small to medium-sized enterprises via the UK Knowledge Transfer Partnership scheme | Technology Transfer, intellectual property | Management | Qualitative research | The UK |
| Walden, R.; Lie, S.; Pandolfo, B.; Lee, T.; Lockhart, C. 2018 | The paper points out some of the challenges associated with research and development for SMEs and argues that designing research units can allow SMEs to meet these challenges better | Joint lecturing and guidance in the production of final theses and papers | Education | Mixed | Australia |
| Kooken, W.C.; Eckhardt, A.L.; McNutt-Dungan, M.; Woods, J. 2018 | Demonstrates fewer formal versions of academic–clinical partnerships established between a small, private liberal arts university school of nursing and two regional clinical agencies | Joint development of curricula and courses | Education | Mixed | The USA |
| Kaklauskas, A.; Banaitis, A.; Ferreira, F.A.F.; Ferreira, J.J.M.; Amaratunga, D.; Lepkova, N.; Ubarte, I.; Banaitiene, N. 2018 | This study sought to create a neural system for a multiple-criteria analysis of university–industry partnership sustainability | All | All | Mixed | Lithuania |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Kesting, T.; Gerstlberger, W.; Baaken, T. 2018 | Develop a multi-step segmentation framework aimed at identifying research customer segments in technical textile industries in Western Europe | All | All | Mixed | Not mentioned |
| Juvonen, P.; Kurvinen, A. 2018 | Present a model for inspiring students to learn through appropriate learning methods and providing them with a modern learning environment comes first, and then ICT and tools | Startups, intellectual property, and patent creation | Management | Action research | Finland |
| Cadiou, J.-C.; Chene, E. 2018 | The article presents an original structuring of the valuation of the research in a university | All | All | Not mentioned | France |
| Rusinaru, D.; Manescu, L.-G.; Ciontu, M.; Mircea, P.-M.; Buzatu, G.-C.; Stoian, G.; Popirlan, C.; Vilceanu, T.; Negoita, A.; Alba, M. 2017 | The paper presents an overview of the knowledge transfer to the industry as secured by the research hub | Technology Transfer, intellectual property | Management | Not mentioned | Romania |
| Berger, S.; Goetz, K.; Leowardi-Bauer, C.; Schultz, J.-H.; Szecsenyi, J.; Mahler, C. 2017 | Lessons learned through the implementation of a planned change to establish four interprofessional seminars are presented | Joint development of curricula | Education | Not mentioned | Germany |
| Ashton, W.S.; Hurtado-Martin, M.; Anid, N.M.; Khalili, N.R.; Panero, M.A.; McPherson, S. 2017 | Share the most valuable lessons from the model, which can be more widely adopted to facilitate industry–academic engagement in the transition to sustainability | Mobility of students within the framework of industrial practice, joint venture | Education | Not mentioned | The USA |
| Jubinville, K.B.; Lynch, A. 2017 | Present and discuss the development of a 3-year bachelor's program in Marketing at a small New England university | Development of dual training programs | Education | Qualitative research | The USA |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Peng, S.; Ferreira, F.A.F.; Zheng, H. 2017 | Develop a firm-dominated incremental cooperation model | Conducting joint R&D | Research | Not mentioned | China |
| Gupta, N.; Jensen, M.J.; Shih, C. 2016 | Share experience with cross-institutional project collaboration | Development of dual training programs | Education | Not mentioned | The USA |
| Thatcher, J.; Alao, H.; Brown, C.J.; Choudhary, S. 2016 | Report on an empirical study analyzing the university/business values derived from one small business engagement project | Joint development of curricula and courses | Education | Qualitative research | The UK |
| Bialek-Jaworska, A.; Gabryelczyk, R. 2016 | Identify the business model components and related attributes of biotech spin-off activity that are key to the implementation of the internationalization strategy | Collaborative networked RDI programs and long-term structures | Research | Qualitative research | Poland |
| Kalnins, J.R.; Jarohnovich, N. 2016 | Analyze what should be done in the case of a small regional university to satisfy regional enterprise and at the same time fulfill the standard university requirements | Joint development of curricula | Education | Mixed | Latvia |
| Wood, D.; Polansky, J.; Cho, M. 2015 | Share experience and collaboration model in Space Nation | Consulting activities | Research | Not mentioned | The USA |
| Matulová, P.; Štemberková, R.; Zdřálek, P.; Marešová, P.; Kuča, K. 2015 | Analyze the state of innovation activities and give an overview of the implementation of innovation vouchers as an effective tool for transferring technology | Technology Transfer, intellectual property | Management | Not mentioned | Czech Republic |
| Bian, J.; Xie, M.; Topaloglu, U.; Hudson, T.; Eswaran, H.; Hogan, W. 2014 | Identifying potential collaborations that are most rewarding by analyzing biomedical research collaboration networks at a research institution | All | All | Mixed | The USA |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Padilla-Meléndez, A.; Del Aguila-Obra, A.R.; Lockett, N. 2013 | Explore the role of social capital in enabling knowledge transfer and exchange (KTE) between higher education institutions (HEIs) and spin-off (academic and non-academic) small and medium-sized enterprises in the context of open innovation | Technology Transfer, intellectual property, spin-offs | Management | Qualitative research | Spain |
| Madsen, S.O.; Brink, T. 2012 | Not available | Not available | Not available | Not available | Not available |
| Vega, A.; Brown, D.; Chiasson, M. 2012 | Explore the policy context and the scope for improvements in university-based programs focused on improving innovation | All | All | Mixed | The UK |
| Chen, J.K.C.; Li, C.S.; Batchuluun, A. 2012 | The study aims to explore a triple helix relationship between firms, universities – government | Startups, intellectual property, and patent creation | Management | Not mentioned | Not mentioned |
| Arquilla, V.; Genco, D.; Mortati, M. 2011 | Share experience on how to find new ways to develop innovation within SMEs through the network | Staff mobility | Research | Not mentioned | Italy |
| Silén, J. 2011 | Not available | Not available | Not available | Not available | Not available |
| Gertner, D.; Roberts, J.; Charles, D. 2011 | Explore the micro-dimensions of knowledge transfer partnerships (KTP) and develop an appreciation of the personal interactions that facilitate the success of these university–industry collaborations | Conducting joint R&D | Research | Qualitative research | The UK |
| Becker, S.A.; Keimer, R.; Muth, T. 2010 | Sharing challenges facing the university and local community in offering the Program to a large and diverse group of entrepreneurs | Mentor training in leadership | Education | Not mentioned | The USA |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Goellner, M.; Warell, A.; Adank, R.; Garrett, L.; Parker, T. 2010 | Provides a novel model for collaboration between industry and academia that focuses on implementing 'design-for-desirability' thinking in SME companies with the aim of competitiveness | Conducting joint R&D | Research | Not mentioned | New Zealand |
| Lino, F.J.; Da Rocha, A.B. 2010 | Share experience about collaboration between universities and industry | Conducting joint R&D | Research | Not mentioned | Portugal |
| Green, J. 2010 | Share experience about the development of undergraduate programs in entrepreneurship and innovation | Development of dual training programs | Education | Qualitative research | The USA |
| Ramos, I.; Cardoso, M.; Carvalho, J.V.; Graça, J.I. 2009 | Develop a business model and technology platform for an innovation brokering service connecting ideas and technologies being developed at universities with the specific innovation needs of SMEs | Technology Transfer, intellectual property | Management | Mixed | Portugal |
| Kasper, L.M.; Schultze, A.E. 2006 | Share how employer outreach goals and initiatives and educational enrichment objectives can be met through cooperative teamwork | Mobility of students within the framework of industrial practice, joint venture | Education | Not mentioned | The USA |
| Peças, P.; Henriques, E. 2006 | Contribute to the implementation of best practices of collaboration between university and industrial small- and medium-sized enterprises (SMEs) | All | All | Mixed | Portugal |
| Lange, J.W.; Wallace, M.; Grossman, S.C.; Lippman, D.T.; Novotny, J. 2006 | Share experiences in building collaboration between nursing students, hospitals, and universities | Joint lecturing and guidance in the production of final theses and papers | Education | Qualitative research | The USA |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Kutinlahti, P. 2005 | The goal is to highlight how Finnish universities have responded to the entrepreneurial demand on the one hand and the significance of their economic role in the firms' innovative activities on the other | All | All | Mixed | Finland |
| Yi, K.; Jung, K.-H. 2005 | The objective of this paper is to introduce a new university–industry collaboration model for small and medium-sized ventures | Joint development of curricula and courses | Education | Qualitative research | South Korea |
| Lloyd, J.W.; Frawley, S.L.; Neer, C.A.; Merle, C.; Goebel, R.A. 2004 | This report describes the development of an innovative model for teaching the principles of financial management as they apply to the veterinary practice | Joint development of curricula and courses | Education | Not mentioned | The USA |
| Boyd, E.; Knox, H.; Struthers, J. 2003 | The authors present a detailed analytical case study of a European-funded Adapt–-University for Industry project that sought to identify training needs and provide guidance and advice on work-based learning opportunities for various Scottish small and medium-sized enterprises (SMEs) | Consulting activities | Research | Mixed | The UK |
| Chang, P.-L.; Hsu, W.-S. 2002 | The experiences gained from Taiwan's university–industry collaborative program are presented through case studies. The framework of the university–industry partnership is presented | Conducting joint R&D | Research | Qualitative research | Taiwan |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Iles, P.; Yolles, M. 2002 | This paper describes one project aimed at developing 'technology translators' and presents a model of viable knowledge management and UIC | Technology Transfer, intellectual property | Management | Not mentioned | The UK |
| Lovett, P.J.; Ingram, A.; Bancroft, C.N. 2000 | The paper explains the underlying mechanisms of Knowledge-Based Engineering and the significant benefits that can be achieved from their application | Conducting joint R&D | Research | Mixed | The UK |
| Bellini, Emilio; Piroli, Giuseppe; Pennacchio, Luca 2019 | This paper builds upon the knowledge-based view and organizational learning perspective. It develops and empirically tests a conceptual model to analyze the drivers and benefits of university–industry cooperation from the firm perspective | Technology Transfer, intellectual property | Management | Qualitative research | Italy |
| Kanter, Rosabeth Moss 2012 | Enhancing the links and collaboration among these universities and businesses can enrich the business ecosystem and help more ideas blossom more job-creating startups launch, and the paper proposes different ways to it | All | All | Not mentioned | The USA |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Panero, Marta A.; Ashton, Weslynne S.; Izquierdo, Christian; Martin, Marta Hurtado; Anid, Nada M. 2018 | The article asks whether the "Pathways" educational model has effectively improved SMEs' environmental and economic performance by helping them reduce their water and energy consumption, along with other measures. To address this question, the authors first focused on the student cleaner production recommendations to analyze their potential impact on SMEs. Then, they quantified the companies' water and energy savings after implementing the student recommendations | Joint development of curricula | Education | Mixed | Latin America |
| Kim, Kelly Y. 2012 | Examine the impact of strategic R&D alliances on biomedical product innovation by small biotechnology firms in the USA | Conducting joint R&D | Research | Mixed | The USA |
| O. A. Ogunleye, 2007 | This study explores the knowledge spillover mechanism in big science projects (BSP) from an institutional perspective by elaborating on the dynamic relationship between institutional dualism and legitimacy | Technology Transfer, intellectual property, spin-offs | Management | Grounded theory | China |
| A. Mourão; A. Gonçalves-Coelho 2008 | The present paper describes the authors' experience in their collaborative work with several SMEs | Joint development of curricula and courses | Education | Not mentioned | Portugal |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| N. Somsuk; P. Punnakitikashem; T. Laosirihongthong 2010 | The model of the analytical hierarchy decision-making process is proposed to examine the relative importance of each resource to the success of the University Technology Business Incubation program | Sharing resources, such as infrastructure and personnel | Management | Mixed | Thailand |
| H. Matheis; M. Tilebein; M. Hirsch; A. Lau 2014 | This paper further elaborates on the overall Smart Networking concept known from former publications and contributes newly developed methods and tools for managing the diversity of collaborative innovation projects | All | All | Design Science Research Process | Not mentioned |
| Yatim, Nurul Huda; Rusuli, Muhamad Saufi Che; Ismail, Mohamad 2018 | Explore the application of Quadruple Helix (QH) in the organizational performance framework of Malaysian small medium and enterprises (SMEs), specifically to find out whether the Quadruple Helix can have a significant impact on the relationships proposed in the conceptual framework | All | All | Not mentioned | Malaysia |
| Deschamps, Isabelle; Macedo, Maria G; Eve-Levesque, Christian 2013 | Shed some light on factors that facilitate open innovation through improved university enterprise collaborations and, more importantly, that attempt to overcome the irritants related to IP management. Our second goal was to analyze the roles of diverse intermediaries in fostering successful collaborations between universities and SMEs | Technology Transfer, intellectual property, spin-offs | Management | Not mentioned | Canada |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Schoephoerster, Richard T; Wicker, Ryan; Pineda, Ricardo; Choudhuri, Ahsan 2011 | Present a case for a dramatic shift in the university–industry relationship for engineering programs, following recommendations from two 2008 reports on the future of engineering education | Development of dual training programs | Education | Not mentioned | Not mentioned |
| Spak, Gale Tenen; Schmitt, Peter; Bandera, Cesar 2011 | This paper will describe the collaboration between a continuing education division of a public research university and a start-up company housed within the university's business incubator | Joint development of curricula and courses | Education | Not mentioned | The USA |
| Mitasiunas, Antanas; Rikure, Tatjana; Novickis, Leonids; Jurenoks, Aleksejs 2011 | This paper describes the further development of the information technology transfer concept for adaptation and exploitation of European research results in the Baltic Sea Region (BSR) countries | Technology Transfer, intellectual property | Management | Mixed | Latvia |
| Eseonu, Chinweike, MSEM; Wyrick, David A, PhD, PE 2010 | Propose an adaptable framework for SMEs and university collaboration | Staff mobility | Research | Not mentioned | The USA |
| Wang, Qingbin; Bauer, Kenneth; Liang, Kathleen 2009 | Review and development of an entrepreneurship program at the university | Development of dual training programs | Education | Qualitative research | The USA |
| Marri, H B; Gunasekaran, A; Kobu, B; Grieve, R J 2001 | Share experience and create a model considering the importance of government–industry–university cooperation | Sharing resources, such as infrastructure and personnel | Management | Qualitative research | The UK |
| Glover, J 2000 | Not available | Not available | Not available | Not available | Not available |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Maghiar, Marcel 2014 | Analyzing factors and impact from industry learning experiences | Joint development of curricula and courses | Education | Mixed | Not mentioned |
| Kirkpatrick, Allan T; Danielson, Scott; Perry, Thomas 2012 | Recommendations about Engineering Education | Joint development of curricula and courses | Education | Not mentioned | The USA |
| Stanfill, R Keith; Mohsin, Arif; Crisalle, Oscar; Tufekci, Suleyman; Crane, Carl 2010 | Create a framework for capturing and sharing with the capstone design community a set of best practices for team mentoring | Mentor training in leadership | Education | Not mentioned | Not mentioned |
| Sanger, Phillip; Ball, Aaron; Clare, Michael; Ferguson, Chip; Graham, John D 2006 | Share experiences about the challenges of the project and demonstrate an exciting application of graduate student and faculty talents to impact the economic development of the regional community | Joint development of curricula and courses | Education | Not mentioned | The USA |
| Ward, Sarah; Butler, David; Adams, Rebecca; O'Callaghan, Sophie; Warren, Neil; Wickett, Mairi; Swire, Hugh; de Mora, Stephen; Uden, Chloe 2018 | Explore the experiences generated through a program of engaged research with the university–society partnerships focused on businesses, climate change impacts, and environmental technologies | Conducting joint R&D | Research | Qualitative research | The UK |
| Varshney, Dinansha; Atkins, Salla; Das, Arindam; Diwan, Vishal 2016 | Understand what these challenges are, which often result in a short-term/non-viable collaboration | All | All | Qualitative research | Not mentioned |
| Nyman, Göte S 2015 | Describe a platform-based, bottom-up approach aimed at solving problems in university–business–government development by facilitating a smooth building of university–business–government collaboration | All | All | Qualitative research | Finland |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Martin Vad Bennetzen; Lars Stig Møller 2013 | Propose a model to accelerate science-based innovation and bridging between academia and society | Conducting joint R&D | Research | Not mentioned | Denmark |
| Calvo, Nuria; Varela-Candamio, Laura; Soares, Isabel; Rodeiro, David 2012 | Study of strategic and organizational determinants in the innovation transfer system and the promotion of university spin-offs | Promoting academic and student entrepreneurship | Management | Not mentioned | Spain |
| Michel, Kathryn K, BA 2014 | Addresses two critical areas for facilitating a solid working relationship between a university and a research center | Conducting joint R&D | Research | Mixed | The USA |
| Wood, Van R; Laric, Michael V; Franzak, Frank; Pitta, Dennis A 2014 | Explore how Technology Transfer Offices (TTO) work (or not) and suggest behaviors that can help TTOs fulfill their commercial and social promise | Technology Transfer, intellectual property | Management | Not mentioned | The USA |
| Alonzo, Crystle N.; Komesidou, Rouzana; Wolter, Julie A.; Curran, Maura; Ricketts, Jessie; Hogan, Tiffany P. 2022 | Share experiences on building and sustaining Research–Practice Partnerships with schools | Joint development of curricula | Education | Qualitative research | The USA |

**Table 3** (continued)

| Author and year | Goal of the paper | Collaboration types studied | Category | Research method | Country of the research |
|---|---|---|---|---|---|
| Yi, HY; Zhang, Q 2022 | Explore how the knowledge-sharing strategies of the enterprise and the university change the Green Technology Innovation level | Sharing resources, such as infrastructure and personnel | Management | Mixed | Not mentioned |
| Khongmalai, O.; Distanont, A. 2022 | Study the key factors that make the technology transfer successful in the context of collaboration between universities, government agencies, and SMEs | Technology Transfer, intellectual property | Management | Qualitative research | Thailand |
| Grimpe, Christoph; Sofka, Wolfgang; Distel, Andreas P 2022 | Explore the outcomes of the coordination process within innovation consortia in which SMEs and universities participate | Conducting joint R&D | Research | Literature review | Not mentioned |

**Abbreviations**

| | |
|---|---|
| HEI | Higher educational institutions |
| MSE | Micro and small-sized enterprises |
| MSME | Micro, small, and medium-sized enterprises |
| R&D | Research and development |
| SME | Small and medium-sized enterprises |
| UIC | University–industry collaboration |

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**Author contributions**
This research work contributes to ET doctoral studies, under guidance of AH. ET wrote the base article and finalized the publication. AH contributed to research proposal writing, data collection, and supervision. ES, EM and SKP structured the content and design of the paper. All authors read and approved the final manuscript.

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**Availability of data and materials**
Not applicable.

## Declarations

**Competing interests**
The authors declare that they have no competing interests.

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**References**

Abdelsalam, A., Happonen, A., Kärhä, K., Kapitonov, A., & Porras, J. (2022). Toward autonomous vehicles and machinery in mill yards of the forest industry: Technologies and proposals for autonomous vehicle operations. *IEEE Access, 10*, 88234–88250. https://doi.org/10.1109/ACCESS.2022.3199691

Abramo, G., D'Angelo, C. A., & Solazzi, M. (2011). Are researchers that collaborate more at the international level top performers? An investigation on the Italian university system. *Journal of Informetrics, 5*(1), 204–213. https://doi.org/10.1016/j.joi.2010.11.002

Adomako, S., & Nguyen, N. P. (2023). Digitalization, inter-organizational collaboration, and technology transfer. *The Journal of Technology Transfer*. https://doi.org/10.1007/s10961-023-10031-z

Ahmed, F., Fattani, M. T., Ali, S. R., & Enam, R. N. (2022). Strengthening the bridge between academic and the industry through the academia-industry collaboration plan design model. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2022.875940

Airaskorpi A. (2023). What is the state of industry-academia collaboration in the social sciences, humanities and arts? Perspectives from the Nordics and beyond. *Vaikuttavuussaatio*. https://www.vaikuttavuussaatio.fi/en/stateofshape/

Airola, M., Salmela, E., & Happonen, A. (2011). Formalising network development in manufacturing SMEs: 6th European Conference on Innovation and Entrepreneurship, ECIE 2011. Proceedings of the 6th European Conference on Innovation and Entrepreneurship, ECIE 2011, 42–50.

Aksoy, A. Y., & Beaudry, C. (2021). How are companies paying for university research licenses? Empirical evidence from university-firm technology transfer. *Journal of Technology Transfer, 46*(6), 2051–2121. https://doi.org/10.1007/s10961-020-09838-x

Amano-Ito, Y. (2020). Introduction of medical device development through industry–academia collaboration by the Hamamatsu method. *Advanced Biomedical Engineering, 9*, 112–116. https://doi.org/10.14326/abe.9.112

Arbo, P., & Benneworth, P. (2007). Understanding the regional contribution of higher education institutions: A literature review. *OECD*. https://doi.org/10.1787/161208155312

Arquilla, V., Genco, D., & Mortati, M. (2011). *The design of a knowledge exchange network between university and SMEs: The DEA experience*. DPPI'11 - Designing Pleasurable Products and Interfaces, Proceedings. Scopus. https://doi.org/10.1145/2347504.2347553

Arvanitis, S., Kubli, U., & Woerter, M. (2008). University-industry knowledge and technology transfer in Switzerland: What university scientists think about co-operation with private enterprises. *Research Policy, 37*(10), 1865–1883. https://doi.org/10.1016/j.respol.2008.07.005

Attia, A. M. (2015). National innovation systems in developing countries: Barriers to university-industry collaboration in Egypt. *International Journal of Technology Management & Sustainable Development, 14*(2), 113–124. https://doi.org/10.1386/tmsd.14.2.113_1

Becker, S. A., Keimer, R., & Muth, T. (2010). A case on university and community collaboration: The sci-tech entrepreneurial training services (ETS) program. In *Cases on Technology Innovation: Entrepreneurial Successes and Pitfalls* (pp. 68–89). https://doi.org/10.4018/978-1-61520-609-4.ch003

Bellini, E., Piroli, G., & Pennacchio, L. (2019). Collaborative know-how and trust in university-industry collaborations: Empirical evidence from ICT firms. *Journal of Technology Transfer, 44*(6), 1939–1963. https://doi.org/10.1007/s10961-018-9655-7

Belso-Martinez, J. A., Xavier Molina-Morales, F., & Mas-Verdu, F. (2013). Perceived usefulness of innovation programs for high-tech and low-tech firms. *Management Decision, 51*(6), 1190–1206. https://doi.org/10.1108/MD-04-2012-0314

Bertello, A., Ferraris, A., De Bernardi, P., & Bertoldi, B. (2022). Challenges to open innovation in traditional SMEs: An analysis of pre-competitive projects in university-industry-government collaboration. *International Entrepreneurship and Management Journal, 18*(1), 89–104. https://doi.org/10.1007/s11365-020-00727-1

Bialek-Jaworska, A., & Gabryelczyk, R. (2016). Biotech spin-off business models for the internationalization strategy. *Baltic Journal of Management, 11*(4), 380–404. https://doi.org/10.1108/BJM-11-2015-0223

Blumberg, S., Ranja Reda Kouba, Suman Thareja, & Anna Wiesinger. (2022). *How to find, keep, and develop tech talent | McKinsey*. https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/tech-talent-tectonics-ten-new-realities-for-finding-keeping-and-developing-talent

Bozeman, B., Fay, D., & Slade, C. P. (2013). Research collaboration in universities and academic entrepreneurship: The-state-of-the-art. *The Journal of Technology Transfer, 38*(1), 1–67. https://doi.org/10.1007/s10961-012-9281-8

Bramwell, A., & Wolfe, D. A. (2008). Universities and regional economic development: The entrepreneurial University of Waterloo. *Research Policy, 37*(8), 1175–1187. https://doi.org/10.1016/j.respol.2008.04.016

Brem, A., Nylund, P. A., & Hitchen, E. L. (2017). Open innovation and intellectual property rights How do SMEs benefit from patents, industrial designs, trademarks and copyrights? *Management Decision, 55*(6), 1285–1306. https://doi.org/10.1108/MD-04-2016-0223

Byrne, J., Fayolle, A., & Toutain, O. (2014). Entrepreneurship education: What we know and what we need to know. In E. Chell & M. Karataş-Özkan (Eds.), *Handbook of research on small business and entrepreneurship* (pp. 261–288). Edward Elgar Publishing. https://doi.org/10.4337/9781849809245.00025

Cai, Y., & Etzkowitz, H. (2020). Theorizing the Triple Helix model: Past, present, and future. *Triple Helix, 7*(2–3), 189–226. https://doi.org/10.1163/21971927-bja10003

Caloffi, A., Mariani, M., Mattei, A., & Mealli, F. (2020). What kinds of R&D consortia enhance SMEs productivity? A hierarchical Bayesian approach for the analysis of a regional innovation policy. *Papers in Regional Science, 99*(1), 25–53. https://doi.org/10.1111/pirs.12476

Caloffi, A., Rossi, F., & Russo, M. (2015). What makes SMEs more likely to collaborate? Analysing the role of regional innovation policy. *European Planning Studies, 23*(7), 1245–1264. https://doi.org/10.1080/09654313.2014.919250

Calvo, N., Varela-Candamio, L., Soares, I., & Rodeiro, D. (2012). Critical analysis of the role of universities in the creation and survival of university spin-offs. Proposal of an academic model of support. *Advances in Management and Applied Economics, 2*(2), 53–82.

Carayannis, E. G., Barth, T. D., & Campbell, D. F. (2012). The Quintuple Helix innovation model: Global warming as a challenge and driver for innovation. *Journal of Innovation and Entrepreneurship, 1*(1), 2. https://doi.org/10.1186/2192-5372-1-2

Cavaliere, V., & Sarti, D. (2011). Knowledge sources, innovation and organizational learning in small firms. *Proceedings of the European Conference on Knowledge Management, ECKM*, 181–189. Scopus.

Chebo, A. K., & Gebrekidan, T. H. (2022). The triple whorl for industrial parks entrepreneurial ecosystem development: Unleashing the integrated role on small ventures growth. *African Journal of Science, Technology, Innovation & Development, 14*(5), 1301–1312.

Cirella, S., & Murphy, S. (2022). Exploring intermediary practices of collaboration in university–industry innovation: A practice theory approach. *Creativity and Innovation Management, 31*(2), 358–375. https://doi.org/10.1111/caim.12491

Clark, B. R. (1998). The entrepreneurial university: Demand and response. *Tertiary Education and Management, 4*(1), 5–16. https://doi.org/10.1007/BF02679392

Cooney, T., & Murray, T. (2018). *Entrepreneurship education in the third-level sector in Ireland*.

Czarnitzki, D., Hussinger, K., & Schneider, C. (2012). The nexus between science and industry: Evidence from faculty inventions. *The Journal of Technology Transfer, 37*(5), 755–776. https://doi.org/10.1007/s10961-011-9214-y

D'Este, P., & Patel, P. (2007). University–industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy, 36*(9), 1295–1313. https://doi.org/10.1016/j.respol.2007.05.002

Davey, T., Baaken, T., Galán-Muros, V., & Meerman, A. (2011). *Study on the cooperation between Higher Education Institutions and Public and Private Organisations in Europe*. https://www.hb.fh-muenster.de/opus4/frontdoor/index/index/docId/4846

de Fátima Cruz, M., Franco, M., & Rodrigues, M. (2022). Exploring university–firm collaboration in teaching: A case study of co-creation. *Industry and Higher Education, 36*(5), 667–679. https://doi.org/10.1177/09504222211049347

Dhillon, H., Qazi, S., & Anwar, S. (2008). *Mitigation of barriers to commercialization of nanotechnology: An overview of two successful university-based initiatives*. ASEE Annual Conference and Exposition, Conference Proceedings. Scopus. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85029105954&partnerID=40&md5=173d324be6cbbf12ba1f94a8b2ea9024

Duzdar, I., Kayakutlu, G., & Sennaroglu, B. (2015). Association rules in innovative technology collaboration. *2015 Portland International Conference on Management of Engineering and Technology (PICMET)*, 220–226. https://doi.org/10.1109/PICMET.2015.7273152

Education Finland. (2023). *Companies*. Education Finland. https://www.educationfinland.fi/companies

Elsevier. (2021). *University-industry collaboration: A Closer Look for Research Leaders*. https://www.elsevier.com/research-intelligence/university-industry-collaboration

Engström, E., & Runeson, P. (2011). Software product line testing – A systematic mapping study. *Information and Software Technology, 53*(1), 2–13. https://doi.org/10.1016/j.infsof.2010.05.011
Eseonu, C., MSEM, & Wyrick, D. A., PhD, PE. (2010). Teaching to the Job: Toward the Development of an SME Relevant Workforce. *IIE Annual Conference. Proceedings*, 1–5. Technology Collection.
Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: From National Systems and "Mode 2" to a Triple Helix of university–industry–government relations. *Research Policy, 29*(2), 109–123. https://doi.org/10.1016/S0048-7333(99)00055-4
Etzkowitz, H., Webster, A., Gebhardt, C., & Terra, B. R. C. (2000). The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm. *Research Policy, 29*(2), 313–330. https://doi.org/10.1016/S0048-7333(99)00069-4
Feldmann, B. D. (2014). Dissonance in the academy: The formation of the faculty entrepreneur. *International Journal of Entrepreneurial Behaviour and Research, 20*(5), 453–477. https://doi.org/10.1108/IJEBR-08-2013-0124
Ferguson, S. (2023). *Understanding America's Labor Shortage: The Most Impacted Industries*. https://www.uschamber.com/workforce/understanding-americas-labor-shortage-the-most-impacted-industries
Galan-Muros, V., & Davey, T. (2019). The UBC ecosystem: Putting together a comprehensive framework for university-business cooperation. *The Journal of Technology Transfer, 44*(4), 1311–1346. https://doi.org/10.1007/s10961-017-9562-3
Galán-Muros, V., & Plewa, C. (2016). What drives and inhibits university-business cooperation in Europe? A Comprehensive Assessement. *R&d Management, 46*(2), 369–382. https://doi.org/10.1111/radm.12180
Geiger, R. L. (2005). Ivory tower and industrial innovation: university-industry technology transfer before and after the Bayh-Dole Act (review). *The Review of Higher Education, 29*(1), 130–131. https://doi.org/10.1353/rhe.2005.0067
Green, J. (2010). *Designing and launching the entrepreneurship and innovation living-learning program for freshmen and sophomores*. ASEE Annual Conference and Exposition, Conference Proceedings. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85029110659&partnerID=40&md5=0d62c1d8635405dab3ab7e9d527230f3
Grimpe, C., & Hussinger, K. (2013). Formal and informal knowledge and technology transfer from academia to industry: Complementarity effects and innovation performance. *Industry and Innovation, 20*(8), 683–700. https://doi.org/10.1080/13662716.2013.856620
Grimpe, C., Sofka, W., & Distel, A. P. (2021). SME participation in research grant consortia-the emergence of coordinated attention in collaborative innovation. *Small Business Economics*. https://doi.org/10.1007/s11187-021-00582-6
Gulbrandsen, M., & Slipersæter, S. (2007). The third mission and the entrepreneurial university model. In A. Bonaccorsi & C. Daraio (Eds.), *Universities and strategic knowledge creation* (p. 12626). Edward Elgar Publishing. https://doi.org/10.4337/9781847206848.00011
Gusenbauer, M., & Haddaway, N. R. (2020). Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. *Research Synthesis Methods, 11*(2), 181–217. https://doi.org/10.1002/jrsm.1378
Hancock, J. I., Allen, D. G., Bosco, F. A., McDaniel, K. R., & Pierce, C. A. (2013). Meta-analytic review of employee turnover as a predictor of firm performance. *Journal of Management, 39*(3), 573–603. https://doi.org/10.1177/0149206311424943
Happonen, A., & Minashkina, D. (2018). *Ideas and experiences from university industry collaboration: Hackathons, Code Camps and citizen participation*.
Happonen, A., Minashkina, D., Nolte, A., & Angarita, M. A. M. (2020a). Hackathons as a company – University collaboration tool to boost circularity innovations and digitalization enhanced sustainability. *AIP Conference Proceedings, 2233*(1), 050009. https://doi.org/10.1063/5.0001883
Happonen, A., Nolte, A., Bystriakova, N., Santti, U., & Kärhä, K. (2022). *Study on Hackathons for New Innovation Seed and Business Model Development Needs in Digitalization Driven Sustainability, Circularity and Environmentally Friendly Solutions Demanding Digitalizing Societies* (pp. 1–29). https://doi.org/10.9734/bpi/niebm/v4/14443D
Happonen, A., & Salmela, E. (2010). *A Global Expansion Model for SME Suppliers in Manufacturing Industries* (pp. 31–40).
Happonen, A., Santti, U., Auvinen, H., Räsänen, T., & Eskelinen, T. (2020b). Digital age business model innovation for sustainability in University Industry Collaboration Model. *E3S Web of Conferences, 211*, 04005. https://doi.org/10.1051/e3sconf/202021104005
Happonen, A., & Siljander, V. (2020). Gainsharing in logistics outsourcing: Trust leads to success in the digital era. *International Journal of Collaborative Enterprise, 6*(2), 150. https://doi.org/10.1504/IJCENT.2020.110221
Helbing, D., & Hausladen, C. I. (2021). *Socio-Economic Implications of the Digital Revolution* (SSRN Scholarly Paper 3771289). https://papers.ssrn.com/abstract=3771289
Hemert, P., Nijkamp, P., & Masurel, E. (2013). From innovation to commercialization through networks and agglomerations: Analysis of sources of innovation, innovation capabilities and performance of Dutch SMEs. *Annals of Regional Science, 50*(2), 425–452. https://doi.org/10.1007/s00168-012-0509-1
Hilkenmeier, F., Fechtelpeter, C., & Decius, J. (2021). How to foster innovation in SMEs: Evidence of the effectiveness of a project-based technology transfer approach. *The Journal of Technology Transfer*. https://doi.org/10.1007/s10961-021-09913-x
Hung, Y.-H., Chen, C.-H., & Huang, S.-W. (2017). Applying augmented reality to enhance learning: A study of different teaching materials. *Journal of Computer Assisted Learning, 33*(3), 252–266. https://doi.org/10.1111/jcal.12173
Iglič, H., Doreian, P., Kronegger, L., & Ferligoj, A. (2017). With whom do researchers collaborate and why? *Scientometrics, 112*(1), 153–174. https://doi.org/10.1007/s11192-017-2386-y
*Intel | Kent State University*. (2023). https://www.kent.edu/cats/intel
Jackson, D., & Collings, D. (2018). The influence of Work-Integrated Learning and paid work during studies on graduate employment and underemployment. *Higher Education, 76*(3), 403–425. https://doi.org/10.1007/s10734-017-0216-z
James, K. L., Randall, N. P., & Haddaway, N. R. (2016). A methodology for systematic mapping in environmental sciences. *Environmental Evidence, 5*(1), 7. https://doi.org/10.1186/s13750-016-0059-6

Jubinville, K. B., & Lynch, A. (2017). *Special Session: Designing an Integrated 3-Year Marketing Bachelor's Degree Program* (p. 1107). Scopus. https://doi.org/10.1007/978-3-319-45596-9_203
Kayser, A. C., Schmidt, S., & Ri, R. S. D. (2018). University-industry collaborative projects: Analysis and proposal of management practices. *Revista De Gestão e Projetos, 9*(1), 24–38.
Keller, S. (2017). *Attracting and retaining the right talent | McKinsey*. https://www.mckinsey.com/capabilities/people-and-organizational-performance/our-insights/attracting-and-retaining-the-right-talent
Kitchenham, B. A., Budgen, D., & Pearl Brereton, O. (2011). Using mapping studies as the basis for further research – A participant-observer case study. *Information and Software Technology, 53*(6), 638–651. https://doi.org/10.1016/j.infsof.2010.12.011
Klawe, M. (2019). *How Educational Partnerships With Industry Benefit Students And Companies: The Clinic Program*. https://www.forbes.com/sites/mariaklawe/2019/11/01/how-educational-partnerships-with-industry-benefit-students-and-companies-the-clinic-program/
Kleiner-Schaefer, T., & Schaefer, K. J. (2022). Barriers to university–industry collaboration in an emerging market: Firm-level evidence from Turkey. *The Journal of Technology Transfer, 47*(3), 872–905. https://doi.org/10.1007/s10961-022-09919-z
Kolk, M., Eagar, R., Boulton, C., & Mira, C. (2018). How hyper-collaboration accelerates ecosystem innovation. *Strategy & Leadership, 46*(1), 23–29. https://doi.org/10.1108/SL-10-2017-0100
Kotavaara O. (2022). *The regional structure of micro and small enterprises' turnover in Finland: The strength of rural areas surprises | University of Oulu*. https://www.oulu.fi/en/blogs/kerttu-saalasti-institute-blog/regional-structure-micro-and-small-enterprises-turnover-finland-strength-rural-areas-surprises
Kovaleva, Y., Kasurinen, J., Kindsiko, E., & Happonen, A. (2024). State-of-the-art review on current approaches to female inclusiveness in software engineering and computer science in higher education. *IEEE Access, 12*, 1360–1373. https://doi.org/10.1109/ACCESS.2023.3346767
Lailiyah, M., Setiyaningsih, L. A., Wediyantoro, P. L., & Yustisia, K. K. (2021). Assessing an effective collaboration in higher education: A study of students' experiences and challenges on group collaboration. *EnJourMe (english Journal of Merdeka): Culture, Language, and Teaching of English, 6*(2), 97. https://doi.org/10.26905/enjourme.v6i2.6971
Lange, J. W., Wallace, M., Grossman, S. C., Lippman, D. T., & Novotny, J. (2006). The journey toward geriatric excellence in a non-research-intensive university. *Journal of Professional Nursing, 22*(2), 84–90. https://doi.org/10.1016/j.profnurs.2006.01.011
Leydesdorff, L., & Etzkowitz, H. (1998). The Triple Helix as a model for innovation studies. *Science and Public Policy, 25*(3), 195–203. https://doi.org/10.1093/spp/25.3.195
Lucy, S. F., Isabella. (2022). *Data Deep Dive: Upskilling and Reskilling Our Workforce*. https://www.uschamber.com/workforce/education/data-deep-dive-upskilling-and-reskilling-our-workforce
Lutenberg, A. (2020). An Approach to the Future of Work: Academia and Industry Alliance to Integrate Work and Study. *The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Conference Proceedings*, 1193–1198. Technology Collection. https://doi.org/10.1109/ICIT45562.2020.9067251
Maghiar, M. (2014). Industry-based Learning Experiences in Project Planning and Scheduling. *Association for Engineering Education - Engineering Library Division Papers*, 24.740.1–24.740.13. Technology Collection.
Marinho, A., Silva, R. G., & Santos, G. (2020). Why most university-industry partnerships fail to endure and how to create value and gain competitive advantage through collaboration – a systematic review. *Quality Innovation Prosperity, 24*(2), 34. https://doi.org/10.12776/qip.v24i2.1389
Matheis, H., Tilebein, M., Hirsch, M., & Lau, A. (2014). Managing diversity of collaborative innovation projects. *2014 International Conference on Engineering, Technology and Innovation (ICE)*, 1–9. https://doi.org/10.1109/ICE.2014.6871587
Meerman, A., Baaken, T., Orazbayeva, B., Davey, T., & Galan Muros, V. (2018). *The state of university-business cooperation in Europe: Executive summary*. Publications Office of the European Union. https://doi.org/10.2766/254490
Mercan, B., & Göktaş, D. (2011). Components of innovation ecosystems: A cross-country study. *International Research Journal of Finance and Economics, 76*, 102–112.
Messina, L., Miller, K., Galbraith, B., & Hewitt-Dundas, N. (2022). A recipe for USO success? Unravelling the micro-foundations of dynamic capability building to overcome critical junctures. *Technological Forecasting and Social Change, 174*, 121257. https://doi.org/10.1016/j.techfore.2021.121257
Michel, K. K. (2014). Liaison and logistics work with industrial advisory boards. *Journal of Research Administration, 45*(2), 61–72.
Minashkina, D., & Happonen, A. (2019). *Enhancing SME companies visibility for international visitors in national exhibition events*.
Minashkina, D., & Happonen, A. (2020). A development of the warehouse management system selection framework as academic-industrial collaboration work with sustainability considerations. *AIP Conference Proceedings, 2233*(1), 050012. https://doi.org/10.1063/5.0001884
Mitchell, D. (2012). The Entrepreneurial University: Or, why the university is no longer a public space (if it ever was). In *Making the University Matter* (pp. 154–161). https://doi.org/10.4324/9780203813027-28
Moşteanu, N. R., Faccia, A., & Cavaliere, L. P. L. (2020). Digitalization and Green Economy—Changes of business perspectives. *Proceedings of the 2020 4th International Conference on Cloud and Big Data Computing*, 108–112. https://doi.org/10.1145/3416921.3416929
Mousavi Baygi, R., Introna, L. D., & Hultin, L. (2021). Everything flows: studying continuous socio-technological transformation in a fluid and dynamic digital world. *MIS Quarterly, 45*(1), 423–452. https://doi.org/10.25300/MISQ/2021/15887
Muscio, A., & Vallanti, G. (2014). Perceived obstacles to university-industry collaboration: Results from a qualitative survey of Italian Academic Departments. *Industry and Innovation, 21*(5), 410–429. https://doi.org/10.1080/13662716.2014.969935
Ndou, V., Vecchio, P. D., & Schina, L. (2011). Open innovation networks: The role of innovative marketplaces for small and medium enterprises' value creation. *International Journal of Innovation and Technology Management, 08*(03), 437–453. https://doi.org/10.1142/S0219877011002404

Nsanzumuhire, S. U., & Groot, W. (2020). Context perspective on University-Industry Collaboration processes: A systematic review of literature. *Journal of Cleaner Production, 258*, 120861. https://doi.org/10.1016/j.jclepro.2020.120861
O'Dwyer, M., Filieri, R., & O'Malley, L. (2022). Establishing successful university–industry collaborations: Barriers and enablers deconstructed. *The Journal of Technology Transfer*. https://doi.org/10.1007/s10961-022-09932-2
OECD. (2022). *Financing SMEs and entrepreneurs 2022: An OECD Scoreboard*. OECD. https://doi.org/10.1787/e9073a0f-en
OECD Publishing. (2017). *Entrepreneurship at a Glance 2017*. OECD. https://doi.org/10.1787/entrepreneur_aag-2017-en
Ogunleye, O. A. (2007). Knowledge transfer partnership: A successful academic-industry relationship in UK with a focus on SMEs. *IEEE International Engineering Management Conference, 2007*, 241–248. https://doi.org/10.1109/IEMC.2007.5235022
Ornellas, A., Falkner, K., & Edman Stålbrandt, E. (2018). Enhancing graduates' employability skills through authentic learning approaches. *Higher Education, Skills and Work-Based Learning, 9*(1), 107–120. https://doi.org/10.1108/HESWBL-04-2018-0049
Pachura, A., & Nitkiewicz, T. (2020). *The role of partnership in launching PBL approach in cooperation with network of social enterprises—Research case of czĚstochowa university of technology*. *10*, 296–303.
Padilla-Meléndez, A., Del Aguila-Obra, A. R., & Lockett, N. (2013). Shifting sands: Regional perspectives on the role of social capital in supporting open innovation through knowledge transfer and exchange with small and medium-sized enterprises. *International Small Business Journal, 31*(3), 296–318. https://doi.org/10.1177/0266242612467659
Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, n71. https://doi.org/10.1136/bmj.n71
Pangarso, A., Sisilia, K., Setyorini, R., Peranginangin, Y., & Awirya, A. A. (2022). The long path to achieving green economy performance for micro small medium enterprise. *Journal of Innovation and Entrepreneurship, 11*(1), 16. https://doi.org/10.1186/s13731-022-00209-4
Perkmann, M., Neely, A., & Walsh, K. (2011). How should firms evaluate success in university–industry alliances? A performance measurement system. *R&d Management, 41*(2), 202–216. https://doi.org/10.1111/j.1467-9310.2011.00637.x
Perkmann, M., & Walsh, K. (2007). University–industry relationships and open innovation: Towards a research agenda. *International Journal of Management Reviews, 9*(4), 259–280. https://doi.org/10.1111/j.1468-2370.2007.00225.x
Petersen, K., Vakkalanka, S., & Kuzniarz, L. (2015). Guidelines for conducting systematic mapping studies in software engineering: An update. *Information and Software Technology, 64*, 1–18. https://doi.org/10.1016/j.infsof.2015.03.007
Plewa, C., Galán-Muros, V., & Davey, T. (2015). Engaging business in curriculum design and delivery: A higher education institution perspective. *Higher Education, 70*(1), 35–53. https://doi.org/10.1007/s10734-014-9822-1
Pokhrel, S., & Chhetri, R. (2021). A literature review on impact of COVID-19 pandemic on teaching and learning. *Higher Education for the Future, 8*(1), 133–141. https://doi.org/10.1177/2347631120983481
Purnomo, D., Pujianto, T., & Efendi, N. (2015). *Unpad—Ibu Popon Collaboration; a Best Practice in Sustainable Assistance Model for Social Entrepreneurship in Agro-industrial based SME's* (A. Guritno, E. Schlich, & E. Pawelzik, Eds.; WOS:000353447700038; Vol. 3, pp. 206–210). https://doi.org/10.1016/j.aaspro.2015.01.040
Rad, D., Demeter, E., Ignat, S., & Rad, G. (2020). Digitization of Everything, the world of 0s and 1s, emerging trends in psychological assessment. *Agora Psycho-Pragmatica*, *14*(1), Article 1. https://uav.ro/jour/index.php/app/article/view/1487
Rajalo, S., & Vadi, M. (2017). University-industry innovation collaboration: Reconceptualization. *Technovation, 62–63*, 42–54. https://doi.org/10.1016/j.technovation.2017.04.003
Ramdan, A. M., Rahayu, A., Wibowo, L. A., & Dirgantari, P. D. (2021). The effect of uniqueness and student's experience in improving university image: Empirical study at private universities in Indonesia. *Management Science Letters*. https://doi.org/10.5267/j.msl.2020.9.034
Richter, D., & Donnerberg, J. (2006). Utilizing Industrial Partnerships To Create Successful Grant Proposals. *Association for Engineering Education - Engineering Library Division Papers*, 11.1421.1–11.1421.7. Technology Collection.
Rodriguez, C. I., Arbuckle, M. R., Simpson, H. B., Herman, D. B., Stroup, T. S., Skrobala, A. M., Sederer, L. I., Appel, A., & Essock, S. M. (2013). Public-academic partnerships: A rapid small-grant program for policy-relevant research: motivating public-academic partnerships. *Psychiatric Services, 64*(2), 106–108. https://doi.org/10.1176/appi.ps.201200519
Rogers, S. E., Miller, C. D., Flinchbaugh, C., Giddarie, M., & Barker, B. (2021). All internships are not created equal: Job design, satisfaction, and vocational development in paid and unpaid internships. *Human Resource Management Review, 31*(1), 100723. https://doi.org/10.1016/j.hrmr.2019.100723
Ruíz-Ruano García, A. M., del Casado Belmonte, M. P., & López Puga, J. (2019). Análisis bayesiano de barreras al emprendimiento en la universidad. *Revista De Educación, 386*, 63–84. https://doi.org/10.4438/1988-592X-RE-2019-386-427
Salbu, B., Skipperud, L., Priest, N., Garelick, H., Tamponnet, C., & Mitchell, P. (2009). European MSc Programs in Nuclear Sciences—To meet the Need of Stakeholders. *AIP Conference Proceedings, 1164*, 85–92.
Salmela, E., Santos, C., & Happonen, A. (2013). Formalisation of front end innovation in supply network collaboration. *International Journal of Innovation and Regional Development, 5*(1), 91–111. https://doi.org/10.1504/IJIRD.2013.052510
Sandborn, P. A., & Prabhakar, V. J. (2015). The forecasting and impact of the loss of critical human skills necessary for supporting legacy systems. *IEEE Transactions on Engineering Management, 62*(3), 361–371. https://doi.org/10.1109/TEM.2015.2438820
Sanger, P., Ball, A., Clare, M., Ferguson, C., & Graham, J. D. (2006). Academic Capability Producing Economic Development: A Success Story. *Association for Engineering Education - Engineering Library Division Papers*, 11.151.1–11.151.7. Technology Collection.
Santti, U., Eskelinen, T., Rajahonka, M., Villman, K., & Happonen, A. (2017). Effects of business model development projects on organizational culture: A multiple case study of SMEs. *Technology Innovation Management Review, 7*(8), 15–26.
Schiuma, G., & Carlucci, D. (2018). Managing strategic partnerships with universities in innovation ecosystems: A research agenda. *Journal of Open Innovation: Technology, Market, and Complexity, 4*(3), 25. https://doi.org/10.3390/joitmc4030025

Schmidt, K., & Mosgaard, M. A. (2020). *How students and companies learned sustainability in mutual Problem Based Learning loops*. 980–989. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85077823641&partnerID=40&md5=5a4aae54a446820b82a9d7abec853c16
Schneider, S., & Kokshagina, O. (2021). Digital transformation: What we have learned (thus far) and what is next. *Creativity and Innovation Management, 30*(2), 384. https://doi.org/10.1111/caim.12414
Shmatko, N., & Volkova, G. (2020). Bridging the skill gap in robotics: Global and national environment. *SAGE Open, 10*(3), 2158244020958736. https://doi.org/10.1177/2158244020958736
Siivonen, J., Pöysäri, S., Hakamäki, A.-M., Lanz, M., Salminen, K., Ijas, M., Aho, M., & Nieminen, H. (2022). Reconfigurable pilot lines enabling industry digitalization: An approach for transforming industry and academia needs to requirements specifications. *Procedia CIRP, 107*, 1226–1231. https://doi.org/10.1016/j.procir.2022.05.136
Silva, P., Lopes, B., Costa, M., Melo, A. I., Dias, G. P., Brito, E., & Seabra, D. (2018). The million-dollar question: Can internships boost employment? *Studies in Higher Education, 43*(1), 2–21. https://doi.org/10.1080/03075079.2016.1144181
*Skills shortage in Finland: A growing challenge amid global trends*. (2023). Helsinki Times. https://www.helsinkitimes.fi/finland/finland-news/domestic/23242-skills-shortage-in-finland-a-growing-challenge-amid-global-trends.html
SME definition—European Commission. (2022). https://single-market-economy.ec.europa.eu/smes/sme-definition_en
Smorodinskaya, N., Russell, M., Katukov, D., & Still, K. (2017). Innovation ecosystems vs. innovation systems in terms of collaboration and co-creation of value. *Hawaii International Conference on System Sciences*. https://doi.org/10.24251/HICSS.2017.636
Sommerauer, P., & Müller, O. (2018). *Augmented reality for teaching and learning-a literature review on theoretical and empirical foundations*.
Stanca, L., Dabija, D.-C., & Păcurar, E. (2021). Community of practice: Converting IT graduate students into specialists via professional knowledge sharing. *Kybernetes, 51*(2), 557–581. https://doi.org/10.1108/K-10-2020-0711
Stanfill, R. K., Mohsin, A., Crisalle, O., Tufekci, S., & Crane, C. (2010). The Coach's Guide: Best Practices For Faculty Mentored Multidisciplinary Product Design Teams. *Association for Engineering Education - Engineering Library Division Papers*, 15.1213.1–15.1213.9. Technology Collection.
Suominen, A., Seppänen, M., & Dedehayir, O. (2018). A bibliometric review on innovation systems and ecosystems: A research agenda. *European Journal of Innovation Management, 22*(2), 335–360. https://doi.org/10.1108/EJIM-12-2017-0188
Taylor, D. P. (2021). *There are examples of these collaborations around the globe.*
Tepper, R. J., & Holt, M. P. (2015). Unpaid internships: Free labor or valuable learning experience? *Brigham Young University Education & Law Journal, 2015*(1), 323–352.
Thomas, V. J., & Maine, E. (2019). Impact of regional systems of innovation on the formation of university spin-offs by biomedical star scientists. *International Journal of Entrepreneurship and Small Business, 37*(2), 271–287. https://doi.org/10.1504/IJESB.2019.100108
Tran, D. (2021). *OECD 2021 Skills Outlook | Digital Skills and Jobs Platform*. https://digital-skills-jobs.europa.eu/en/latest/news/oecd-skills-outlook-2021-why-lifelong-learning-essential-modern-society
Van Den Berg, C. (2019). *Teaching digital innovation: Collaboration between students and entrepreneurs*. *2*, 1061–1068. https://doi.org/10.34190/ECIE.19.078
Vega, A., Brown, D., & Chiasson, M. (2012). Open innovation and SMEs: Exploring policy and the scope for improvements in university-based public programmes through a multidisciplinary lens. *International Journal of Entrepreneurial Behavior & Research, 18*(4), 457–476. https://doi.org/10.1108/13552551211239492
Verdugo-Castro, S., García-Holgado, A., & Sánchez-Gómez, M. C. (2022). The gender gap in higher STEM studies: A systematic literature review. *Heliyon, 8*(8), e10300. https://doi.org/10.1016/j.heliyon.2022.e10300
Wang, Q., Bauer, K., & Liang, K. (2009). Toward a multidisciplinary entrepreneurship education: A case study of the community entrepreneurship program at the University of Vermont. *International Journal of Innovation and Regional Development, 2*(1–2), 84–95. https://doi.org/10.1504/IJIRD.2010.029856
Wendji, C. M., & Pilag Kakeu, C. B. (2022). The effect of external knowledge on innovation capacity of SMES: Does the source of knowledge matter? *African Journal of Science, Technology, Innovation and Development, 14*(6), 1655–1666. https://doi.org/10.1080/20421338.2021.1979170
Widmaier, T., Juhanko, J., Piili, H., Kuosmanen, P., Salminen, A., Happonen, A., Kontio, J., & Nyrhilä, O. (2013). Digital design and manufacturing process comparison for new custom made product family – a case study of a bathroom faucet: Kohandatud tootepere digitaalne disain ja tootmisprotsess – vannitoa valamusegisti näide. *Estonian Journal of Engineering, 19*(1), 76. https://doi.org/10.3176/eng.2013.1.07
Wood, D., Polansky, J., & Cho, M. (2015). University partnerships as a model for capability building in emerging space nations. *International Astronautical Congress. Jerusalem, Israel, 6*, 4260–4282.
Wynn, M., & Jones, P. (2019). Context and entrepreneurship in knowledge transfer partnerships with small business enterprises. *International Journal of Entrepreneurship and Innovation, 20*(1), 8–20. https://doi.org/10.1177/1465750318771319
Yi, H., & Zhang, Q. (2022). Knowledge-sharing strategies of university-industry alliances promoting green technology innovation in ecosystems: Based on the utility of multichannel funding. *IEEE Access, 10*, 65728–65743. https://doi.org/10.1109/ACCESS.2022.3184422
Yusuf, S., & Nabeshima, K. (2007). *How Universities Promote Economic Growth*. World Bank Publications.
Zilvinskis, J., Gillis, J., & Smith, K. K. (2020). Unpaid versus paid internships: group membership makes the difference. *Journal of College Student Development, 61*(4), 510–516. https://doi.org/10.1353/csd.2020.0042

## Publisher's Note



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