A framework to improve university–industry collaboration

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Abstract

Purpose – The purpose of this paper is to propose a framework to improve the effectiveness of university–industry collaboration (UIC). This work enhances the existing body of literature and knowledge regarding collaboration and offers concrete steps to be taken for effective collaboration between universities and industries.

Research Methodology – A literature review to study the best practices, impediments to collaboration and the various models proposed in the past for successful UIC was conducted. A workshop and focus-group meetings of practitioners and academic researchers was designed and organised to explore the current state of the university–industry engagement within the Australian Capital Territory (ACT) region and gather inputs regarding possible approaches to improve collaboration. The findings from the literature review and the results from this qualitative research regarding the approaches to improve the effectiveness of the collaboration were analysed.

Results and implications – The study discovers that various measures have been proposed in the form of best practices or models to improve the effectiveness of UIC. However, these measures often address a specific concern such as technology transfer, intellectual property (IP), etc. There is a scope for a comprehensive holistic framework to address many aspects of UIC in order to improve effectiveness and achieve success. A framework for improving the effectiveness of collaboration considering a comprehensive list of factors operating in a broad context within the collaboration system was proposed.

Originality/value – The framework builds on previous literature dealing with measures for successful UIC. However, it is the first of its kind, in the researcher's knowledge, in terms of comprehensiveness of the factors contributing to establishing and sustaining successful collaboration. The value of the individual experience of the participants in this qualitative research, which is on average more than 10 years in the software engineering field, validates the importance and quality of the data collected. The addition of these results to the framework increases its validity.The framework can be utilised by universities and industry practitioners to foster successful and effective collaboration. The results have significant relevance, particularly within the Australian context as the government has intensified the adoption of measures to encourage and improve collaboration between universities and the industry.

Keywords University–industry collaboration, UIC, Collaboration, Framework, Practices

Paper type Research paper

1. Introduction

We are dealing with a volatile and highly competitive global environment (Alonso *et al.*, 2010). Such a competitive environment requires organizations to innovate at a fast pace to deliver new products and services in order to meet the demands of consumers (Magdaleno *et al.*,

2011). Organizations are struggling to attain a competitive edge in this global market fostered by new economies of scale (Alonso *et al.*, 2010). Collaboration has become a pervasive topic as an imperative instrument to overcome these organizational challenges (Demircioglu and Audretsch, 2019; Mendibil Telleria *et al.*, 2002; Alonso *et al.*, 2010). Moreover, the influence of the digital revolution at the personal and organizational level is changing socioeconomic aspects and the way of interoperation and collaboration among individuals and enterprises (Alonso *et al.*, 2010). The need and advantages of collaboration have been recognized, yet many organizations still find it difficult to encourage and establish collaborations (de Wit-de Vries *et al.*, 2019; Magdaleno *et al.*, 2011; Borrelli *et al.*, 1995). There are accelerated efforts to encourage collaborations, and existing literature points out several types of collaboration forms. However, it is still challenging for organizations and universities to identify the best practices to follow in order to establish and sustain collaboration. This has led to the increasing need for establishing some practices and principles to guide the initiation, implementation and success of a collaboration.

The purpose of this paper is to propose a framework to improve the effectiveness of university–industry collaboration (UIC). The framework is based on the inputs from a workshop conducted by us, and the thorough review of the literature regarding the best practices for collaboration. This framework, proposed to facilitate the partnerships and improve the effectiveness of UIC, offers concrete steps to be taken for effective collaboration between universities, industry, government and other stakeholders. The outcome of our work enhances the existing body of literature and knowledge regarding collaboration, and is expected to offer practical benefits to various stakeholders who influence or are influenced by the collaboration.

The structure of this paper is as follows: Section 2 provides an overview of the methodology of the research; Section 3 describes the best practices for successful collaboration proposed in the existing literature; Section 4 explains the results of our qualitative study focused on the measures to be adopted by universities to improve collaboration; in Section 5 we describe the proposed framework for improving the effectiveness of UIC; in Section 6 we discuss the implications of our work; and, finally, we present the overall conclusions and future work in Section 7.

2. Research methodology

2.1 Literature review

A review of the available research was carried out on the topic related to university–collaboration. The search for relevant papers, articles, proceedings and reviews was carried out using Google Scholar and other journal websites. We considered the publications focused on the best practices for successful UIC.

2.2 Qualitative data collection

The human-centric nature of software engineering (Seaman, 1999) makes qualitative data collection an essential instrument to gather useful information. We designed and organised a workshop and focus group meetings of practitioners and academic researchers to explore the current state of the university–industry engagement within the Australian Capital Territory (ACT) region, their perception of the gap between university research and industry practice and barriers to collaboration between them. We also gathered inputs regarding possible approaches to bridge the gap and improve collaboration.

The overall goals of the workshop and focus group meetings were to

(1) understand the perception of university–industry engagement among industry practitioners and academics,

(2) elicit possible measures to improve the current situation by increasing engagement and

(3) identify the ways in which universities can play a larger role in bridging the gap.

As our main focus was software engineering research and practice, we identified researchers in computer science and experts in the software industry in Canberra. We invited 20 participants through email for the workshop along with a Doodle poll attached for scheduling the workshop in April 2016. Since not all the interested participants were available at the same time, we decided to conduct a workshop on the day when most of the participants were available. We organized two separate focus group meetings to cover the remaining interested participants based on their availability. In this way, seven participants (six from the industry background and one university researcher) in total attended a workshop and two separate meetings in April-May 2016.

The workshop and meetings were semi-structured to address a similar agenda, yet provided enough opportunity for the participants to express their views and discuss their experiences around university–industry collaboration and ideas to improve it. These generally lasted for about two hours each. We recorded the discussion on a digital device for further analysis. This resulted in three recordings from the workshop and two separate meetings. We also took some notes during the process to serve as a backup in the event of a recording failure or voice loss.

3. Best practices: existing literature
Literature provides evidence of the efforts towards the formulation of best practices for successful university–industry collaboration from various perspectives in several studies (Edmondson *et al.*, 2012; Tornatzky *et al.*, 2002; Cyert and Goodman, 1997; Prigge, 2005; Greitzer *et al.*, 2010; Sandberg *et al.*, 2011).

From universities' perspective, academic leadership (Edmondson *et al.*, 2012; Rahm *et al.*, 2013), focus on long-term strategic partnerships with flexibility (Calder, 2007; Edmondson *et al.*, 2012) and shared vision and strategy to achieve the goal (Rohrbeck and Arnold, 2009) are important factors playing a role in the success of a collaboration with industry. Individuals with an understanding of both academic and business worlds are considered the driving force behind successful partnerships (Edmondson *et al.*, 2012). Universities must involve people with networking and managerial skills to attract industry partners. At the same time, academics with industry background are an added advantage as they are expected to be more willing to cross boundaries and network with people beyond their area of expertise. Universities need to redefine their mission, and collaboration with industry needs to be included as an important part of the role of research universities (Edmondson *et al.*, 2012). There is an emphasis on universities' actions at the administrative level to overcome the barriers related to university–industry collaboration and improve their potential to succeed. In order to achieve successful university–industry collaborations, academic administrators must ensure that an environment is sustained which is conducive to achieving the academic missions of teaching, research and service, preserves the financial and academic integrity, allows engaging in technology transfer with security of the public interest and ensures objectivity and balance in supporting the programmes related to the university's mission (Zinser, 1985; Prigge, 2005). An indication towards an extended role to be played by universities through engaging with other stakeholders, primarily government, in policy formulation is also evident (Zinser, 1985).

For universities, importance of policies in sustaining collaboration is recognized, and four 'policy targets' have been identified in order to overcome some of the barriers to UIC: long-term development of industrially relevant academic R&D resources, improvement of communication between university and industry (de Wit-de Vries *et al.*, 2019), reduction of the

financial/material costs of interaction and the resolution of institutional conflicts and filling role gaps at the university–industry interface (Stankiewicz, 1986). In the long-run, the success of a policy depends on the alignment with the established academic system. This can be achieved by collaboration among institutions for developing a common policy to address conflicts of interests for their faculty and organizations (Angell, 2004). According to Holbrook and Dahl, 'universities have made good faith efforts to limit conflicts of interest and commitment on the part of individuals and institutions by crafting and revising policies to meet the changing features of the research environment' (Holbrook and Dahl, 2004). However, it is essential for governments to set guidelines and mandate to restrain universities from going on alone in their own direction (Krimsky, 2004).

On the industry side, a strong commitment leading to a continued interest in the project during its development stages and in its results is a significant factor for fostering successful collaboration (Barbolla and Corredera, 2009; Rahm et al., 2013). It is expected to result in extensive participation from industry personnel in establishing the research agenda followed by reviewing the research progress and results. Consideration of project by corporate as highly useful in practice, the confidence of the industrial partner in the expertise of the academic team and strong interest of the corporate in utilizing the outcomes of the project are conclusive factors for the success of a collaboration (Barbolla and Corredera, 2009). These factors tend to impact the commitment of an industry partner. This is a recognition of the fact that the industry's role is equally important, and universities and industries contribute complementary elements to the collaborative venture.

Absorptive capacity is an additional attribute that contributes to the successful technology transfer and sustained collaborative activities (Rahm et al., 2013; Philbin, 2008). For the successful transfer of knowledge and technology, industrial partners should have the internal capability to absorb the research fully and transform it into marketable products. It is further facilitated by the presence of industrial personnel having a level of research sophistication matching with that of the university.

Another perspective to efforts for effective collaboration is the identification of problem selection, teamwork, process management and information dissemination as the key elements in building effective relationships between universities and companies (Cyert and Goodman, 1997). It is evident that Cyert and Goodman focused on the university–industry collaboration process itself and proposed the actions to be taken from the outset of the collaboration process until the delivery of results for its success. They address the collaboration primarily from the perspective of 'problem-solving' as the main motivation, though they suggest measures to overcome some of the common barriers such as information dissemination.

'Boundary spanners' have been identified as key players in establishing and sustaining the relationships (Thune, 2007; Calder, 2007). One of the main ideas to overcome the obstacles related to intellectual property rights is establishing an intermediary (Valentín, 2000). Several researchers extol the worth of an 'agent' in ensuring the actual knowledge transfer during a collaborative research project (Bloedon and Stokes, 1994; Calder, 2007; Prigge, 2005). The agent performs monitoring, management and administration of the project. Boundary agents strongly influence the value of an industry-sponsored project in collaboration with university (Calder, 2007).

Results of another study of partnerships between university research centers (URCs) and industrial firms in the USA indicate that social connectedness, URC technology transfer, intellectual property policies, trust, technological relatedness and technological capability are significant facilitators of knowledge transfer (Santoro and Bierly, 2006). These relationships are also influenced by the type of knowledge being transferred, that is, explicit versus tacit.

Recognizing the cultural and organizational differences, Burquel highlights the need for universities and industries to adapt to each other's cultures and requirements (Burquel, 1997). She recommends that universities develop 'new modes of operation, institutional leadership

and more flexible institutional management' in order to establish successful collaboration. Rohrbeck and Arnold suggest some measures to overcome the cultural barriers such as postdoctoral students possessing an inherent interest in application-oriented research should be employed, policies related to publications and intellectual property rights should be clearly defined and interaction should be improved by means of a central coffee shop, co-location with stakeholders, biyearly off-sites and policy to enhance transparency (Rohrbeck and Arnold, 2009). Any successful relationship requires a positive attitude from partners, mutual respect and a commitment to the collaborative venture (Dryden and Erzurumlu, 1996; Prigge, 2005). While the differences in the culture and philosophies of collaborating partners are considered to bring more creativity on the table, strategic alliances between them need to be nurtured carefully over a period of time to arrive at desired stability in the relationship (Ehrismann and Patel, 2015). In order to achieve a win-win scenario, all the stakeholders in a collaborative venture should approach them with a new mindset that considers and values each other's different missions (Dryden and Erzurumlu, 1996). This indicates the significance of the selection of appropriate partners, as emphasized in the literature (Barnes *et al.*, 2002).

Intellectual property negotiations have been formidable barriers to forming effective UIC. There is a need to overcome the legal barriers associated primarily with intellectual property rights. Ways to overcome such obstacles associated with university–industry collaborations include a legal framework for the cooperation must be established; contracts must include exclusivity clauses; constraints on information should be minimized; there should be vertical integration of the collaboration in the partnering organizations; and the use of intermediaries should be promoted (Valentín, 2000). Universities are encouraged to reconsider their policies regarding technology transfer and intellectual property rights. They should target to establish shared and enforceable guidelines to limit disclosure restrictions (Florida, 1999). According to Burnside and Witkin, it is possible to overcome legal barriers and reduce the IP negotiation period from 20–26 to 1–2 months by using a model to facilitate team-creation, draft an agreement on the predetermined process and committing towards designing creative ways of agreement (Burnside and Witkin, 2008).

Researchers emphasize the importance and need of understanding the nature of partnerships given a variety of interactions are available to achieve different objectives (Farrell, 2010; Bloedon and Stokes, 1994). A portfolio of the variety of linkages suitable to meet different requirements improves the effectiveness of collaboration (Bloedon and Stokes, 1994). This can be attributed to the possibility of making an informed decision in selecting a type of interaction suitable to the particular context and achieving the set objectives.

Social capital resources, which include trust, mutual obligations, common understanding, access to information and opportunities, play a crucial role in the formation and success of collaborations (de Wit-de Vries *et al.*, 2019; Thune, 2007). Pierre Bourdieu defined the social capital concept as 'the aggregate of the actual or potential resources which are linked to possession of a durable network of more or less institutionalized relationships of mutual acquaintance or recognition' (Bourdieu, 1986; Portes, 1998). Bourdieu's definition indicates that social capital can be decomposed into two elements: 'first, the social relationship itself that allows individuals to claim access to resources possessed by their associates, and second, the amount and quality of those resources' (Portes, 1998). Organizational commitment and availability of resources through networks appear to be a prerequisite for university–industry interactions. Strategies with a focus on boundary spanning and mobility can be an enabler for fostering collaborations.

4. Approaches to improve U-I collaboration: workshop

An iterative process was followed to analyse the data recorded during the workshop and two focus group meetings. Recordings were carefully listened to and transcribed. These transcripts

were later read multiple times to identify the categories and classify the comments into them. The findings from the data analysis can be classified into the following two broad categories:

(1) Barriers to university–industry collaboration.

(2) Approaches to improve this collaboration.

We discuss here the relevant results, which are associated with the approaches to improve the UIC (Complete details of the qualitative study are available in an earlier publication (Awasthy *et al.*, 2017)). Participants in the workshop and the focus group meetings agreed that university–industry engagement is a complex problem. It needs an intervention with a diversity of approaches to move closer towards a solution so that benefits can flow to a wider community. The barriers are related to the individual as well as organizational behaviour and strategy. Behavioural barriers such as trust and mindset issues are more challenging to address. However, universities can adopt a few measures to overcome some of the barriers and bridge the gap to establish and sustain successful collaboration. We describe below the measures proposed during the research, with a focus on universities' role to increase university engagement:

(1) **Proactive Role of Universities** – Participants expressed the view that universities need to play a more proactive role in the commercialization of research results. They need to demonstrate the applicability of research for industry in a relevant context and promote their research outcomes. Before this, they need to gain a better understanding of the requirements of business and users around them. This will help universities to align their research goals for greater impact.

(2) **Collaborative Platform** – To address the lack of visibility of the university research, universities need to create a platform where people can reach out to relevant contacts to discuss ideas and achievements. It became apparent from this qualitative research that digital platforms have been underutilized and there is a need to focus on providing an online medium to connect people for sharing ideas and working together. However, there is a concern about the willingness of people to share their research ideas. This can be addressed by adopting a university strategy to encourage people to network, gain mutually and share.

(3) **Entrepreneur Skills to Drive Research Adoption** – Participants had a view that improving research adoption is also a matter of passion. Researchers need to try to network and promote their research. Universities need to employ people with entrepreneurial characteristics whose goal is to make things happen. Along with this, universities need to work towards employing and preparing staff who are academically qualified to understand the research and its significance and can talk the language of business and marketing people. One way to achieve this is to invest in graduate and postdoctoral students as they possess the required expertise, and are often more open to alternative career pathways rather than standard academic pathways. In fact, universities can also utilize the potential of academics who are transitioning to retirement.

It is also worth collaborating within the university to explore the application side research and mature it by bringing the technology readiness level (TRL) up. While it is a good idea to explore research applications within the university, it should be kept in mind that positive response within the university does not indicate wider industry adoption, as they both are different worlds.

(4) **Awareness about Product/business** – The participants also recognized the value of awareness among researchers about a product and its life cycle. Understanding the

real product and its contributing environment will lead to increased engagement between researchers and industry. It will also broaden the perspective of researchers about their work. Universities need to encourage such relationships.

(5) **Education** – Researchers need to be educated and trained to think beyond the narrow confines of their research outcome as a publication, to the real-world application of their research. There is a need to create awareness among researchers about pitching their research in the right context of application to industry to create an impact.

(6) **Improve Alumni Association** – The participants highlighted the value of the greatest asset of a university: its people, especially alumni. Universities should maintain a connection with alumni and share the progress within the university. Good and continued relationships with alumni can contribute to increased industry engagement, funding for research, donation and broader societal impact.

5. Collaborative framework
It is evident from the review described in the previous section that several 'best practices' have been formulated for successful collaboration. However, these best practices are scattered through the literature, and some authors have focused on only one aspect of collaboration such as technology transfer or problem-solving. Our aim is to propose a generic framework considering several aspects of the variety of interactions possible between universities and industry. We analysed the best practices for successful collaboration described above and derived a framework for improving the effectiveness of UIC. This framework considers a comprehensive list of factors operating in a broad and wide context within the collaboration system. The underlying hypothesis for this framework is that creating an enabling environment will result in more effective collaborations.

(1) **Understand the Variety of Interactions** – As a starting point, it is very important to understand the various kinds of interactions or relationships that are possible between universities and industry. Different types of interactions have different degrees of involvement and duration, and offer specific benefits. An understanding of the nature of those interactions will allow the stakeholders to make an informed decision about selecting a partnership suitable to the context.

(2) **Identify the Stakeholders** – Observing the bigger picture of collaboration indicates the presence of several stakeholders. Rombach and Achatz (2007) identify some stakeholders as universities and basic research institutes (e.g. Max-Planck Gesellschaft in Germany), applied research institutes (e.g. Fraunhofer Gesellschaft in Germany), start-up companies, research-based companies (e.g. Siemens Corporate Technology), development-based companies (e.g. Siemens Business Units) and consulting companies. Another study identifies stakeholders in business research as experts and resources, research and teaching, students, organizations and companies, industry and business interests (Chartered Accountants Australia and New Zealand, 2017). It is critical for engaging parties to identify a set of strategic partners to collaborate with. While focusing on strategic partnerships, the value of non-strategic partnerships should not be ignored, as they have their own benefits in a particular context.

There is a need to establish a partner evaluation method in order to ensure the selection of partners who have genuine interest and commitment, and adequate resources to support the intended research project (Barnes *et al.*, 2002). Characteristics to consider during the selection of a stakeholder are the relevance

of the problem, complementary nature of resources and absorptive capacity of the firm in case of technology transfer. It is also important to consider prior experience with stakeholders, as earlier short-term successful partnerships are expected to lead to long-term strategic partnerships. Once the partners have been identified, there is a progress towards developing a shared vision. There should be a clear articulation of the amount of active contribution expected from the industry partners at the beginning of the collaborative partnership. 'The higher the complementarity of capabilities between partners, the higher the likelihood of mutual trust and the higher the level of mutual commitment' (Das and Teng, 2000; Chartered Accountants Australia and New Zealand, 2017).

Identifying the stakeholder and the problem to be addressed are intertwined. Thus, they are not sequential and may randomly follow each other.

(3) **Understand the 'Why' – Identify the motivation** – Universities and industry have invariably different motivations for collaborating. It varies from problem-solving, resource-sharing or information/people access to skills development through education. It is important to identify motivations and common areas before co-working or collaborating. Claus Otto, programme manager at Royal Dutch Shell PLC, says, 'It is important to ask yourself: What can these university centers do better or different than we can?' (Perkmann and Salter, 2012). This requires due time, discussion and deliberation. If the motivation is problem-solving, stakeholders should select a problem that possesses intellectual rigour and is motivating for both the partners. The problem should complement academic expertise and be relevant to the industry. Universities should also aim at selecting a generalizable problem within the partner organization, as it will have wider applicability leading to greater impact for the organization and the partnership. Such a selection of problem and solving it with a 'consideration of use' is expected to enhance its impact.

'Business needs what the university has to offer because they won't succeed unless they innovate' (Chartered Accountants Australia and New Zealand, 2017).

(4) **Identify and Appoint Suitable People and Involve Leadership** – It is to be noted that characteristics of individuals and an organization influence the level of collaboration. Universities should identify the key university staff and faculty suitable for interactions: '...achieving a high level of collaboration depends on participants who contribute an openness to change, a willingness to cooperate, and a high level of trust' (Jassawalla and Sashittal, 1998). Young researchers are typically more suitable for identifying the characteristics of the economic environment. Involving and engaging people who cross boundaries have a positive impact on the relationships. The industry should select capable managers for effective project management. Appointing the right people is the key to the success of a collaboration. Sometimes these may be intermediary agents such as technology transfer offices or boundary-spanning managers/agents. Sector representatives must be introduced to each other for a better understanding of the collaboration objectives, processes and expected outcomes. Entrepreneurial behaviour of leaders is believed to influence the effectiveness of collaboration. University leaders must also get involved, as strong university research leadership indicates the commitment of a university and influences the formation and success of collaborations. Universities should take a step further and participate in the processes of national policy formulation.

Industry leadership must have a vision about what is worth creating and the foundations that support the vision. Leadership is demonstrated in the ability to identify and understand the roadblocks and in finding ways to overcome them (Chartered Accoun- tants Australia and New Zealand and RMIT, 2017). As Carse

says, 'Finite players play within boundaries; infinite players play with boundaries'
(Carse, 1986). Universities should take the leadership role while businesses employ
their potential in playing with boundaries between organizations, domains and
capabilities.

(5) **Ensure Basic Partnership Characteristics** – For the success of a partnership,
it is important to ensure some basic set of principles to work under. Stakeholders
should identify a win-win situation and agree upon it and work under an agreed
framework, ensure a long-term commitment. Long-term commitment is
demonstrated by the level of engagement in the form of people and resources
from each stakeholder from the beginning of interaction until the final phase.
Extensive university support and industrial personnel participation in establishing
the research agenda and reviewing the research progress and results should be
ensured. Last but not least, government support and encouragement to
collaboration can lead to the formation and success of collaborations.

(6) **Establish Efficient Communication** – Interpersonal communication is a critical
factor in the success of a relationship. Company and university leaders must
understand each other. Stakeholders should adopt measures to improve
communication between them, such as being in regular contact to meet and talk
regularly, engaging with the partner daily (if required) and utilizing various modes
of communications such as mobile, digital media and face-to-face talks.
Communication and monitoring need to be well implemented for fostering
communication, including the follow-through processes. Progress reports should
be made available at various stages of collaboration. Communicating the benefits of
the collaboration can stimulate future collaborations. Regular access to top
management should also be provided for the successful collaboration.

(7) **Strengthen the Dissemination Strategy** – Universities must work towards
strengthening their dissemination strategy and to using elements of marketing for
sharing the research results along with their rigour and relevance to attract new
partners. They should use a variety of channels to enhance the dissemination of
results, leading to improved industrial adoption of research such as increased contact
with consumers of knowledge, validating the applicability of research results in a
client-centric way and formally creating new positions as knowledge brokers in
academia.

(8) **Address IP Concerns** – It is advisable that the value of a partnership should be
seen in terms of other benefits rather than getting hung up on intellectual property
(IP). A common understanding must be developed among everyone about
intellectual property. Partners should minimize constraints on information, and
universities should not seek to overprotect IP to prevent IP from becoming a
stumbling block. In some cases, stakeholders should agree to drop claims.
Establishing shared and enforceable guidelines limiting disclosure restrictions,
limiting conflicts of interest and agreeing on a clear IP framework will help in
overcoming the legal barriers associated with UICs.

(9) **Adopt Policies to Encourage/facilitate Collaboration** – Successful
collaborations need to be encouraged and supported by policy interventions.
Institutions must collaborate to develop a common policy on conflicts of interest for
themselves and their faculty. Policies should help in resolving institutional conflicts
and filling role gaps at the university–industry interface. Policies must be revised to
meet the changing features of the research environment while preserving the

academic and financial integrity. Universities should work towards the reduction of the financial/material costs of interaction and long-term development of industrially relevant academic R&D resources. Stakeholders should also participate in the processes of national policy formulation and influence it for increased benefits.

(10) **Adopt Strategy to Encourage Collaboration** – Successful collaborations, often, are a result of the commitment of the partners shown by making collaboration a part of their strategy. Stakeholders need to listen to each other and seek ways to work together. This is facilitated by developing a clear strategy. A good strategy for collaboration will include deliberate and informed planning, identification of key contracts using environmental scanning, adopting a legal framework for cooperation and proper preparation. Strategies should aim at developing new partnerships and supporting existing projects to launch new opportunities. Research universities need to redefine their role as a source of competence and problem-solving for society.

(11) **Focus on Social Capital Resources** – Social capital resources include trust, mutual obligations, common understanding, access to information and opportunities. The existence of mutual trust is an important factor leading to effective knowledge sharing between various stakeholders and contributing to the success of the collaborative venture.

Individuals demonstrating entrepreneurial skills are believed to foster the network competence of an organization. The network competence refers to the ability of a team to develop and utilize relationships with external stakeholders such as research institutes, industry and government bodies (Walter *et al.*, 2002). Network competence significantly influences the effectiveness of collaboration activities.

(12) **Setup Rewards and Incentives** – A new system of incentives should be created in universities to recognize the efforts of the academics participating in partnerships with industry. Rewards and incentives are expected to influence the motivations and level of engagement of individuals, leading to more effective collaborations.

(13) **Management of the Collaboration** – It is important to manage collaborations. Adopting a framework to manage the collaboration process in a similar manner as the software development life cycle will help in monitoring, course-correction during the collaboration process and achieving the set goals.

(14) **Alumni Association** – Universities need to maintain connection with their graduating students who would work in industry or become an entrepreneur in future. Connection with those students is an opportunity for university to discuss industry problems and understand ways of working together to solve those relevant problems. These alumni can become mentors for present cohort of students. 'By developing long-term relationships with the university, graduates help the university to re-learn' (Chartered Accountants Australia and New Zealand, 2017).

6. Discussion and implications
In this paper, we have proposed a collaborative framework of practices to improve university–industry collaborations. The literature review highlighted the interest and efforts towards recommending the 'best practices' for establishing collaboration and improving its effectiveness. It revealed that the data are fragmented, and there is scope as well as a strong requirement to provide more comprehensive data for the best practices to initiate, develop and effectively manage UICs that will provide practical benefits to academia and industry. The literature review, as well as the workshop findings, indicate various factors influencing

the success of a collaboration. We identified varied forms of interactions, problem/motivation, people, social capital, basic partnership characteristics, communication, dissemination, IP, strategy and policy as the factors to be considered in our framework for improving the effectiveness of collaboration. We hypothesize that ensuring the quality of underlying factors will lead to the success of a collaboration. However, achieving it would involve a significant effort, deeper understanding and experience.

The complex nature of the collaboration process makes it difficult to guarantee a success formula. However, the proposed collaborative framework is expected to improve the effectiveness of collaboration as it adopts a holistic view of collaboration and focuses on the driving forces and enablers to successful collaboration, rather than processes. It attempts to provide necessary guidelines to various stakeholders for establishing and sustaining successful collaborations. While the framework here focuses on university and industry, it is expected to find wider applicability and flow benefits to other stakeholders as well within the ecosystem.

We understand that the sample size of our qualitative research is small and focused on the area of software engineering. It does not necessarily represent the entire population of university–industry relationships. However, the value of the individual experience of the participants, which is on average more than 10 years in the software engineering field, validates the importance and quality of the data collected. The study may also face external validity issues such as research results may not be generalized to settings outside of Australia. However, the inputs to the framework heavily rely on the findings of literature generated across the globe in varied settings, which add a promising value to the resultant collaborative framework.

This research and the proposed collaborative framework have implications for university and industry collaborations as follows. This research makes a theoretical contribution to the advancement of knowledge in the field of UIC. In our knowledge, it is the first of its kind effort to bring together a comprehensive set of practices. The literature review highlighted the importance of the 'best practices' for establishing university–industry collaboration and improving its effectiveness. This research has managerial implications as the framework provides a useful tool for practical application for informed decision-making to improve the effectiveness of UICs and increase their success probability. The results have significant relevance, particularly within the Australian context as the government has intensified the adoption of measures to encourage and improve collaboration between universities and industry. We expect that the application of the framework in a real-life scenario will lead to the further emergence of best practices that can be reused in a similar context in the future. The experience may also result in the development of new practices that can be added to the framework. This indicates the fluid, dynamic and open nature of our framework.

7. Conclusion
In this paper, we have proposed a framework to improve the effectiveness of UIC. The framework is based on the review of the best practices for collaboration proposed in the existing literature. Literature around best practices for university–industry collaboration appears to be scattered, and this framework is an effort towards creating a comprehensive set of best practices. Our framework is further informed by the findings of qualitative research involving practitioners and researchers in the field of software engineering conducted to understand the current state of university–industry collaboration and elicit the ways to improve collaboration between the two entities. The study contributes to enhancing knowledge regarding the university–industry collaboration and improving its effectiveness. By following the proposed framework, universities and industries can establish a collaboration, which is expected to be more effective and successful. Future research is planned to evaluate the framework.

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