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Design and Science: A workshop-based approach for identifying commercial opportunities in universities

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Abstract: Universities are expected to play an important role as drivers of innovation and economic growth. Despite efforts to match these expectations, the commercialisation of scientific research remains poor. Issues in the commercialisation of research that have been identified in previous literature include scientists' lack of business skills, poor understanding of industry needs and lack of funding for development. However, there is a lack of studies proposing practical tools to bridge the gap between research and the market.

Studies analysing the activities of certain technology companies propose using workshops to assist technology innovation. However, the method for using these workshops in universities remains unexplored. This paper aims to explain why the workshops should include designers assisting scientists if used in the academic context. It takes recommendations from literature and uses interviews with multiple scientists developing technologies to inform the design of the multidisciplinary workshop structure.

Keywords: multidisciplinary collaborations; design and science; technology development; research commercialisation

1. Introduction

Universities' scientific research is a key factor identified to a nations' ability to innovate, generate and sustain economic growth (Mansfield & Lee, 1996). This has recently been substantiated in Australia, with the National Science and Innovation Agenda (NISA) aimed at leveraging scientific research to generate new business opportunities. In addition to generating new knowledge, the Australian government funding structures expect university research to impact the economy, society, environment or culture (Government, 2019). Studies have shown that universities have been reacting to these expectations by increasingly modifying their mission to encourage science commercialisation (Rasmussen, Moen, & Gulbrandsen, 2006). However, despite universities efforts to increase research impact and collaboration with industry, in some countries such as The United Kingdom,

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commercialisation of research remains poor (Livesey, Minshall, & Moultrie, 2006). Others, like Australia, show poor university-industry collaborations (OECD, 2017). This gap between university research and the market is referred to by Wessner (2005) as the 'the valley of death'.

This paper proposes that designers and scientists need to work together in the university context if they aim to match the research impact expectations of governments and universities. It explains why design and science should collaborate, and focuses on practical methods that utilise designers' skills set to align scientific research with commercial opportunities early in the technology development process.

Technology Management literature recommends using technology roadmaps to align technology development with commercial opportunities in tech-based companies and suggests using multidisciplinary workshops to facilitate this process (Phaal, Farrukh, & Probert, 2007). It also recommends to analyse market trends and create future scenarios as technologies require a long time to be fully developed (Brem & Voigt, 2009). Based on these various recommendations, the authors propose using multidisciplinary workshops with designers and scientists in the university context. The methods reviewed in the literature refer to those used by technology companies. How such tools can be used in universities to assist in scientific research remains to be explored. Therefore, this paper explains how these workshops can be implemented in an academic context.

Interviews with multiple scientists developing technologies were used to inform the workshop design relevant for an academic context. The design researchers also used the interviews to understand the readiness of the scientists to participate as co-creators. Based on the analysis of the interviews, the authors propose a workshop structure where possible future scenarios are used as stimuli for generating ideas. These scenarios are based on existing literature analysing market, user and technology trends. This work is part of a more extensive PhD research study that seeks to test different design activities in scientific research based on the framework for technology development (Mesa, Thong, Ranscombe, & Kuys, 2019). This work is undertaken with the science Centre for Translational Atomaterials' of Swinburne University of Technology.

In the context of this paper, multidisciplinary collaborations will be understood as different disciplines working together and providing different views on a problem based on their expertise (Stember, 1991). The word 'co-creation' has been used in multiple contexts as explained by (Ind & Coates, 2013). In this paper, co-creation will describe the joint effort of designers and scientists generating and refining ideas and concepts together with a shared objective. 'Design' refers to the activities of people with specific procedural training to create practical design artefacts across communication, industrial, service and digital design fields.

Technology or knowledge transfer offices play a significant role in the commercialisation of university science. However, these activities are generally derived from business and entrepreneurship disciplines and are outside the scope of this paper.

This paper seeks to answer the following research questions:

RQ1: What are “key points” to take from existing activities used by technology companies to identify commercial opportunities through workshops?

RQ2: What “key points” should be emphasised when implementing workshops for technology development in universities?

This work explores literature describing the challenges scientists face in recognising commercial opportunities from their research. Then, it identifies how designers’ skills can assist scientists in this process. To answer the first research question, the authors analyse technology management literature and the recommendations of authors in this field. For the second research question, this paper presents the results of eight in-depth semi-structured interviews that helped in understanding technology development in universities. Based on the interview results, this study proposes a multidisciplinary workshop to assist opportunity recognition in scientific research in universities. The paper focuses on science that may lead to novel technology development, and acknowledges that not all university science should or needs to be commercialised.

2. Scientists’ challenges, designers’ strengths

2.1 Scientists’ challenges identifying commercial opportunities

Different studies have analysed the reasons for the low commercialisation rates of universities’ scientific research. According to Würmseher (2017), scientists’ lack of business skills is one of the main reason for their commercial failures. Compounding this, Würmseher (2017) explains that scientists fear that commercialising technologies negatively affects their academic careers. Zappe (2013), reflecting on his own scientific career, argues that scientists usually do not understand industry needs and motivations. Zappe explains that in some science fields like physics, chemistry, engineering and biology there is a vast gap between an exciting result that can be published in ‘Nature’, and its embodiment into a form that can be used by a company to start the development of a product. Even in technology-based companies, recognising an opportunity for commercialising is far from easy; managers usually underestimate the time and effort required to develop new technologies, causing premature insertion into the market (Eldred & McGrath, 1997).

Expecting scientists to be excellent researchers and at the same time to be experts in marketing, product design and business is not fair or realistic. Here lies an opportunity to explore how other disciplines can collaborate with science. This paper is concerned specifically with how designers can do this, with a focus on university science as the context.

How can we then — as designers — assist scientists through multidisciplinary collaboration to facilitate the translation of their work?

2.2 Designers' skills and contributions to science when collaborating with scientists

Before understanding how designers' skills can complement scientists' commercialisation activities, it is essential to understand the difference between both disciplines. Roozenburg and Eekels (1995) argue that scientific enquiry *analyses and understands* the natural world to create new knowledge. Design, in contrast, uses knowledge to *transform* the natural world. This idea is also supported by Rust (2004). He explains that while scientists focus on understanding and exploring what already exists, designers focus on invention and novelty. Therefore, the identification of commercial opportunities for new technologies sits between the interests of both disciplines. Simply put, a scientific project requires finding a market need — or predicting one — if it is expected to be transformed into a commercial technology product.

Previous studies describe how designers can assist scientists in conducting research. For example, Rust (2004), Driver, Peralta, and Moultrie (2011) explain that designers can imagine new and future scenarios to assist scientists in understanding the potential usability of technologies. Simeone, Secundo, and Schiuma (2017), based on the work of Sainsbury (2007), explain that design can assist scientists in developing commercial applications during research stages. After analysing multiple collaborations between designers and research institutions, a study by DesignCouncil (2015) reports that designers can help scientists identify commercial opportunities for their work. Driver et al. (2011) found through case studies that designers ability to do market and user research can enhance the commercial potential of the outputs of scientific research. Moultrie (2015), continuing the identification of design contributions to science, found that in early stages of scientific research visualising potential future applications was critical to the case studies. As the authors put it: "these visualisations stimulated discussion regarding the enabling science and the likely market potential".

Simeone et al. (2017) focus on understanding the role of designers in collaborative activities. They point out that designers can help multidisciplinary groups ideate through graphical representations such as prototypes, sketches and data visualisation. Simeone et al. (2017) found that design enables knowledge sharing and translation of ideas between stakeholders.

Analysing designers' skills, Crismond and Adams (2012) state that experienced designers delay decision making in terms of defining a solution for a problem. Through market research, technological investigations, and doing brainstorming, designers gather a clearer understanding of problems to come back with multiple solutions for them (Crismond & Adams, 2012). These activities conducted by designers complement the research skills of scientists.

3. Adapting tech management tools to the university context

3.1 Industry practices for opportunity recognition in early stages of technology development

The problem of identifying commercial opportunities for new research is not exclusive to universities. To understand how to deal with the innovation issues in companies, Brem and Voigt (2009) study the approach of a thriving technology firm in Europe. The study highlights that workshops mixing internal and external experts in technology, marketing and regulation represent a central first stage in commercialising research (as illustrated in Figure 1). Within workshops, trends are identified and discussed alongside technology competence and corporate interests of the company. The goal of workshops is leveraging a team of different experts to define future scenarios for the next 5 to 10 years. After the scenarios are fully analysed, ideas for new products and services are generated. The authors explain that the success of these workshops depends on the right mix of people from different disciplines, ideally those known for being innovative and creative.

Figure 1 Triggers and key elements in technology innovation management (Brem & Voigt, 2009).

Alongside the workshop activities mentioned above, technology roadmapping (TRM) is cited in technology management literature for assisting the innovation process (Probert, Farrukh, & Phaal, 2003). TRM help align markets with technical competences, resources, technologies and products to identify the best commercial opportunities for organisations (Phaal et al., 2007). Phaal et al. (2007) propose a workshop based TRM uniquely suited for innovation process and identification and exploration of opportunities. The authors say that traditionally, the workshops aim to set organisational short- and long-term goals. In terms of participants, they concur with Brem and Voigt (2009) who suggest having a multifunctional team representing both the technical and commercial side of the company. Phaal et al. (2007) also go on to propose a workshop structure consisting of six main stages:

1. Planning: Determine the aims, roadmap architecture, participants, logistics and workshop agenda.
2. Workshop stage (a): a strategic landscape is developed based on brainstorming. It aims to capture perspectives in areas of interests and critical issues.
3. Workshop stage (b): Opportunities are identified and prioritised using the strategic landscape from the previous stage.
4. Workshop stage (c): Opportunities are explored in more depth and roadmaps are constructed and presented in small groups.
5. Workshop stage (d): The opportunities are reviewed, learning points identified and a plan of action is set.
6. Review: At a suitable time, the execution of the technology roadmap is reviewed to ensure that the plan of action is being executed.

Figure 2 illustrates the structure of a traditional technology roadmap; the graphic representation constructed with the workshops. The roadmap shows how the different ideas, driven by multiple experts, are aligned with future opportunities. The work by Phaal et al. (2007) shows that the purpose of TRM workshops is to create divergent thinking and explore many ideas, before converging in the most attractive opportunity. This process, typical in design, is similar to the renowned ‘double diamond’ design process proposed by DesignCouncil (2005) (see Figure 3).

Figure 2 Traditional technology roadmap structure adapted from (Phaal et al., 2007).

Figure 3 Double diamond design process adapted from DesignCouncil (2005).

Based on the key literature discussed in this section we can see that workshops with multidisciplinary stakeholders are crucial at the start of technology commercialisation and that divergent and convergent idea exploration are vital activities. The next section will summarise the key elements of technology innovation in companies and will explain how these can be adapted to universities using design-science collaborations.

3.2 Integration of technology roadmapping into the academic context and the role of design

The works of Brem and Voigt (2009) and Phaal et al. (2007) (previously reviewed) describe the characteristics that contribute to successful technology innovation management; including the important role that workshops play in that process. Below, ten key elements are highlighted in these works that must be considered when designing these types of workshops:

1. Define a clear strategy and long-term goals before selecting a project for development.
2. Include experts and people from different areas with decision-making power to steer the technology project.
3. Analyse market, user and technology trends to understand the upcoming future.
4. Consider legal, political, sociocultural, environmental and environmental policies that may affect the projects.
5. Create future scenarios based on the trends analysed.
6. Maintain frequent communication with people from different departments to understand their insights.
7. Give all participants a voice to contribute to the ideas and share their knowledge.
8. Have people understanding the technical side of the technology and people that can understand markets and users.
9. Have innovative and creative participants in the workshop.
10. Define a plan of action with all the participants involved in the project.

These activities include market research, understanding of users, the creation of future scenarios and teamwork. As presented in the review of the literature in section 2.2, these are skills that designers are trained for; and it has been shown that they can assist scientists in their research (Driver et al., 2011; Moultrie, 2015; Rust, 2004; Thong & Kuys, 2012). In other words (and as previously explained in section 2.2), once knowledge is generated by scientists, the design domain can translate how this knowledge (technology) can be embodied into a product.

4. Research approach

4.1 Interviews: objectives and planning

As presented in the previous section, a key imperative for tech-based companies is making sure that there is an appropriate strategy and clear goals defined. While literature reviewed suggests conducting workshops with experts from different departments to create technology roadmaps, the potential value of this in university contexts is unexplored. Universities rarely have focused areas aligned to commercial goals, but they do have experts from multiple disciplines. Thus, we contend there is an opportunity to leverage this diversity with collaboration activities such as multidisciplinary workshops.

Before proposing a structure for multidisciplinary workshops, it was necessary to understand scientists' motivations, incentives and approaches to technology development. For these reasons, interviews were conducted. These interviews with scientists informed the plan for a workshop suitable for the specific university setting needed and the level of maturity of the technology to be explored.

The interviews had a checklist of topics, but some questions were covered more in-depth depending on each participant expertise, as recommended by (Robson, 2011 p.285). Following Robson's recommendations to avoid biased answers, the open-ended interview questions were carefully selected so the participants could share their own thoughts and opinions. The themes covered by the interview were: scientific project selection; understanding of designers' skills; roles in technology development; and tools used to assist technology development and commercialisation.

4.2 Sample demographic data

The interviews targeted eight scientists with different backgrounds and varied research experience (see Table 1). The reasons behind this were to see if each scientist had different views on technology development according to their experiences as academic researchers and if they had different project management.

Table 1 Interviewees' demographic data.

Participant	Age	Background	Gender	Position	Research field
Scientist 1	30-34	Physics	Male	Post-Doc	Micro-photonics
Scientist 2	25-29	Robotics engineering	Male	PhD student	Micro-photonics
Scientist 3	30-34	Physics	Female	Post-Doc	Bio-Photonics
Scientist 4	20-24	Materials science	Female	PhD student	Micro-photonics
Scientist 5	30-34	Electronic engineering	Male	Post-Doc	Integrated photonics
Scientist 6	40-44	Optics and economics	Female	Professor	Micro-photonics
Scientist 7	50-54	Physical chemistry and biophysics	Male	Professor	Bio-Photonics
Scientist 8	50-54	Engineering and chemistry	Male	Professor	Biomaterials

4.3 Analysis of Interview data

As the objective was understanding the thoughts of the scientists and the meaning of the answers, thematic analysis was selected as the analysis method. The data segments were grouped in themes and then further coded in subthemes; until no more were identified, as suggested by Gilbert (2008, p.259-264). The codes were labelled using meaning condensation; a method where the answers of the interviewees are compressed into short sentences (Kvale & Brinkmann, 2009, pp. 205-207).

4.4 Interview results

THEME 1: SCIENTISTS' GENERATIVE MINDSET AND SELECTION OF PROJECTS

Most of the scientists highlighted that they like solving problems and generating new knowledge. The results show that they target research areas based on trending research topics. When asked about the process to conduct research and select projects; the answers indicated that the professors in charge of the group are the ones steering most of the group research, or at least the primary goals.

"Well, I think the final goal, and at least one of the individual goals are provided by our supervisors. They will give us most of the guide for how or what kind of small targets we have to reach" (Scientists 1).

One of the professors said:

"The main thing is a unique contribution that highlights our expertise. Then, if I think that it is an important project for us, and I think that it is where we should be focusing on, the decision is made" (Scientists 7).

As one of the recommendations from technology management literature was including multiple experts while selecting the projects, teamwork and a co-creation approach should be emphasised in the workshop to mitigate the issue of one person taking critical decisions on their own. When the scientists were asked how the research projects were selected for development, most of them replied that the process is done by comparing experiment results to other publications in the field, looking what other scientists did before, and

attending conferences to identify “hot topics” and research trends. Only one professor, who had been previously involved in technology development and commercialisation, explained that maintaining frequent communication with clinicians (end-users of his research) was essential for defining selection criteria for his projects (see Figure 4).

Figure 4 Illustration of “Scientist 8” management approach for scientific research projects.

Despite most interviewees being aware of the importance of understanding industry needs, only one scientist mentioned defining a commercialisation strategy. Furthermore, none mentioned conducting market research, reviewing trends or defining future scenarios. The lack of awareness of the importance of these activities, already identified in this paper as key elements for identifying commercial opportunities for new technologies, is an indicator that they should be the focus of the multidisciplinary workshop.

THEME 2: SCIENTISTS’ UNDERSTANDING OF DESIGNERS’ SKILLS

The results showed that scientists did understand that design could contribute to technology commercialisation; however, they had different opinions and highlighted different designers’ skills.

“I think we, as scientists, do not have a very good idea of how a product that needs to be sold into the market has to look like. So, we definitely need someone who has that knowledge” (Scientist 3).

“We are doing research from the fundamental end and then the design is more from the real product end... if we can meet somewhere or guide the design from the very beginning, that would be a very efficient way” (Scientists 6).

One scientist talking about his previous experience with a designer said:

“They (designers) allowed the project to expand considerably in areas where we never ever thought it would go into and it was directly attributed to getting more funding as well. Because we do not just have a project based on a material, we have a project-based around a holistic approach to developing a product. Things that material scientists would never think of” (Scientist 8).

Although the interviewees understand some of the benefits of working with designers, it was not clear for most of them — with the exception of the professor who worked with designers before — when designers should be called to collaborate, and in what degree it would be beneficial for their research group.

THEME 3: DISCIPLINES' INVOLVEMENT IN TECHNOLOGY DEVELOPMENT FOR COMMERCIALISATION

The analysis shows that the scientists interviewed understand that they play a role in technology development; however, some of them still think that the commercialisation of technology is industry's responsibility.

When asked who should champion the technology to market some interviewees replied:

"To market? The industry. In terms of marketing, access to market, all those things, the industry is responsible... I would leave that to them" (Scientists 2).

"Tech companies. I think that researchers develop new techniques and these companies, who are developing techniques as well would like to buy those patents and prototypes from researchers; to move or push them into the market if they want to" (Scientists 4).

The interviews showed that although scientists' knowledge that other disciplines can assist technology commercialisation, most of them did not know when the right time was to reach them or what resources are available in the university for this process. Again, only the scientist who had been involved in research commercialisation before knew the importance of working with other disciplines. However, even he said he did not enjoy the process:

"This transition into commercialisation, I am getting more and more into it. Probably 5–6 years ago I did not like it at all. I just found it very different and very confusing, in terms of what to do... I was more comfortable back in what I was familiar with; analysing the data...In more recent time I'm getting to get excited about commercialisation" (Scientist 8).

As the process to commercialise technology is not clear for scientists, the workshop should make emphasis on explaining and using tools as technology roadmapping. These tools are expected to help them align their resources and technologies with commercial opportunities adding clear short- and long-term goals. Additionally, the workshop should provide a space for multidisciplinary interaction that can make clear the role of other disciplines in the process of commercialisation.

THEME 4: SCIENTISTS' UNDERSTANDING OF TECHNOLOGY MANAGEMENT TOOLS

During the interviews, the scientists did not indicate using technology management tools or structured methods. Each interviewee described a different process for managing research and developing technologies based on their knowledge. The lack of experience using the tools recommended by literature could be a challenge for implementing the workshop; scientists could consider it irrelevant and unfamiliar. Therefore, before conducting each activity of the workshop, the objectives need to be explained. As designers are familiar with brainstorming and teamwork, we also recommend having at least one designer in each team participating in the workshop.

5. Workshop preparation and structure

Based on the recommendations from literature, and the insights from the interview analysis, the researchers suggest that the following set of activities are conducted to prepare content for the workshop. The workshop organiser (preferably a designer with experience conducting workshops) and the scientist/s that lead the scientific research group of the technology should be involved in preparation.

1. Accurately measure the current state of research: It must be defined what the technology can currently do and the “know-how” of the group. It can help identify short-term commercial opportunities. A fair judgement is required, as a very optimistic strategy can lead to unrealistic objectives setting (Rec 1, Theme 1).
2. Define a realistic projection of the technology performance if it is further refined: This activity will assist the brainstorming process during the workshop as it will help to imagine how the technology could be implemented in future scenarios as well as identifying long term goals and ideating disruptive technology applications (Rec 8).
3. Summarise existing commercial agreements and current funding sources: The scope of the intellectual property agreements needs to be understood before ideating applications. The explorations of commercial opportunities cannot create legal issues for the group. Overlapping developing efforts will have adverse effects and conflict with existing funding partners.
4. Understand potential routes to market: The challenges and implications of exploring different entrepreneurial approaches must be discussed – such as licensing or creating spin-offs (Würmseher, 2017).
5. Define the advantages and limitations of the technology: This requires both identifying other research projects with similar development objectives and other technologies in the market with similar properties. Based on this comparison, that should include technical data, limitations and advantages of the research should be identified.
6. Defining a commercialisation strategy: Once all other considerations are considered, a strategy should be defined to exalt the strengths of the technology and the group. Even before applications are ideated, the group should know their competitive advantages.
7. Analyse market, user and technology trends: Trend reports help identifying the critical problems in the upcoming future as well as the socio-cultural challenges that will define how people interact with products (Rec 3, Theme 1).
8. Define future scenarios: Identify in the trend reports categories that can be grouped in different scenarios. Each scenario should describe in short sentences the main problems and challenges of the upcoming future, considering socio-cultural, environmental, political, legal, economic and technological influences (Rec 5).

5.1 Workshop design

Generally, the workshop follows the model of “design charrette” as proposed by Hanington and Martin (2012). We now describe the specific details relevant to the context of design science collaborations.

STAGE 1 – IDENTIFICATION OF MARKET SECTORS AND OPPORTUNITIES FOR EACH FUTURE SCENARIO

The workshop facilitator, preferably a designer with experience conducting co-creation workshops, starts explaining the workshop objectives and presenting the participants. The facilitator role is controlling time and presenting and moderating the activities. A quick icebreaker activity helps get in the “creative mood”. Then, participants are evenly split into teams and each given a future scenario. Each team is provided with a whiteboard, sticky notes and markers. Each participant is asked to write down as many market sectors and opportunities for the assigned scenario in a few minutes. Then, using mind-maps, each team is asked to organise the ideas on a whiteboard and to identify as many sub-categories as possible. When each mind-map is saturated, half of the team members rotate to the next whiteboard/trend to provide ideas in a different context.

STAGE 2 – IDEATION OF APPLICATIONS FOR THE MARKET SECTORS

The technology being researched by the scientists is briefly introduced and explained to all participants in simple words. Then, a similar process of individual ideation and team changing is repeated. However, this time the ideation is around how the technology could be used in different products to solve particular needs in each of the market sectors previously identified.

STAGE 3 – SELECTION OF CONCEPTS AND CLASSIFICATION

When ideas are saturated, and participants slow down the idea generation process, they are asked to go around each whiteboard selecting their favourite technology applications. Then — again in teams — the most voted concepts are classified in a desirability, feasibility and viability diagram. The diagrams are presented to the rest of the participants and then there is a discussion of the workshop results. These applications can be further classified in technology roadmaps by the head of the scientists with assistance of the design facilitator.

6. Discussion

There are two main challenges that still need to be explored. First, the openness of scientists and designers to engage in this type of activity. This relates to the second challenge; the incentives for designers to engage in these collaborative activities are not yet identified. It may change from one institution to another, but for collaboration to succeed it is essential to identify benefits and workloads for every person involved.

The workshop and the preparative activities suggested in this work will be tested with a group of scientists developing graphene-based energy storage technology. The results will be

analysed and presented in another manuscript. After, it is aimed to continue exploring how these tools can be applied to other technologies being developed in the university. As the use of these tools is unexplored in literature, it needs to be applied with different university technologies to test replicability.

After analysing the literature in this field, more questions arise; to what extent do technology companies use co-design activities? Can this co-creation workshop tool be tested with similar technologies in industry? To be able to answer these more research is required. The role that different design disciplines may play in this co-creation activity and the desire to engage is still unknown, as it may be related to the organisations desire to innovate. Is commercialisation of technology only dependant to the head of the scientific group? What is the role of individuals and university mechanisms? Finally, it must be mentioned that co-creation activities done with trend analysis and future scenarios may not only be useful to identify commercial opportunities, but to identify undesirable outcomes before technologies are developed.

7. Conclusions

This paper has explored the literature of technology management to identify best practices to apply in universities. It has also shown that designers have the skills necessary to assist scientists in applying those recommendations. Moreover, the study collected data from interviews to understand the scientific research process before proposing tools for identifying commercial opportunities in this environment. Finally, based on the recommendations from literature, and the knowledge acquired from the interviews, this paper proposed a workshop structure that allows the combination of scientists' technical knowledge with designers' generative and teamworking skills.

The interviews showed that scientists are aware that designers can contribute to their work and are aware that designers have a better understanding of users and industry needs. However, scientists do not seem to know mechanisms to collaborate with designers, and literature does not provide tools to assist this process. Only one scientist, who worked with designers before, understands in-depth the value of these collaborations. Therefore, this study furthers the idea of the importance of design and science collaborations for technology development and commercialisation in universities and proposes a multidisciplinary workshop as an initial bridge between disciplines.

The proposed workshops have the potential to help identify commercial opportunities early in scientific exploration. However, the tool still needs to be tested, and the potential of implementing technology roadmaps in university contexts further explored.

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