INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
8–9 SEPTEMBER 2022, LONDON SOUTH BANK UNIVERSITY, LONDON, UK

LESSONS LEARNED FROM A DESIGN-DRIVEN ENTREPRENEURSHIP PROCESS THAT BRIDGES ACADEMIC RESEARCH AND DESIGN EDUCATION

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ABSTRACT
Research and education can be distinctly separate activities in institutions, where academics try to divide their time between the two roles. Many research initiatives necessitate large-scale funding to be completed. In response, this paper presents an alternate strategy in which educational design initiatives can promote academic research activities. The study looks at how a design-led entrepreneurial approach combines research and education to create marketable solutions. A literature review was undertaken to understand the disconnect between academic pedagogy, postgraduate, design-driven research and design entrepreneurship. An undergraduate Product Design degree course was also examined to understand the means through which innovative solutions are incubated. We then applied our findings to progress a final year project through master's level with a commercial focus to determine the viability of our approach. This study presents findings and lessons learned from a paradigm built inside a research cluster, in which viable design proposals are incubated as undergraduate final year projects (FYP) and then selected for postgraduate development with the goal of commercialization. A variety of difficulties and possibilities, as well as lessons learned, were recognized, including choosing the right topic to develop, forming partnerships with different disciplines, intellectual property, money, expertise, and resources. By bringing together the often-separate entities of research and education, this paper shows how research and educational activities are not mutually exclusive but can be combined to provide rich educational experiences along with meaningful research outputs.

Keywords: Innovation, entrepreneurship, design, health and wellbeing, research

1 INTRODUCTION
Universities are now at the front of innovation and entrepreneurship with calls for them to be competitive and sustainable as funding from state departments is reduced [1]. While research, entrepreneurship and innovation are at the forefront of university activity it is often disconnected from the educational role of universities. Education often retains a more inferior position over academic research, to the point of being neglected [2]. While institutions teach both theoretical and practical subjects, there is criticism that some programmes that offer entrepreneurship are, applying outdated curriculum and pedagogical techniques that do not connect students to industry and the workplace [1, 3]. However, design programmes have the potential to be the foundation for entrepreneurship to drive and support design driven entrepreneurial research in academic institutions. This paper describes a model where design education and entrepreneurial research can coexist and become embedded to create mutual benefits for both entities.
It also describes how design programmes can be a catalyst for design and innovation research and potential commercialization, through cross collaboration within academic institutions.

2 LITERATURE REVIEW
The relationship between education and research is a contemporary issue [4]. Education through research is specific to the specific aims of the project, whereby the application of already established design pedagogy seeks to solve specific design issues, as opposed to using those issues as a learning

experience. However, design practice and research have begun to become intertwined, the results of which have produced "practitioner-researchers" [5]. While there has been a limited emergence of "new practitioners", whose skillsets combine practice, education, and research in one compound skillset, it is still a relatively new concept, and potentially underutilised [6]. However, there are also many aspects to the future of design which are uncertain, as design professions evolve and change [7]. Current design education runs the risk of having students specialising in areas that may be irrelevant as these professions evolve [4]. This is further exacerbated by the disconnect between research and education, as research focuses more on contemporary design issues whereas education may lag behind in that regard, potentially favouring outdated concepts of learning and teaching to inform design [8]. Design research is less concerned about producing knowledge as an end in itself, but instead focuses on making new things possible [4].

Design driven innovation in academia has grown due to the central role of design thinking in innovation, and the well-documented increase in technology transfer over the past few decades [9-11]. Many universities have a well-established technology transfer infrastructure to both encourage and promote entrepreneurship as its own subdomain within academia [12, 13]. To that end, design driven innovation is a key contributor to technology transfer due to the broad nature of design research, as well as its involvement in other domains such as engineering, healthcare, and science [14-17]. Design entrepreneurship can enable academic institutions to spinout commercially viable research projects companies to acquire further funding to continue growth and IP development [18-20]. Funding bodies such as the European Commission’s “Design for Enterprises” the European Design Innovation Initiative (EDII) support design-driven innovation in Small and Medium Enterprises and academia [21, 22]. Through these initiatives, universities and other academic settings have developed their own commercial outputs through both academic research and industry collaboration [23, 24].

However, there is a disconnect between academic pedagogy and postgraduate, design-driven research, whereby the educational aspects and research aspects are kept separate. In design education, tools, skills, methods, processes are taught to students for them to competently enter the design profession [4]. It can be argued that design educators prefer to teach general, basic design fundamentals which ensures their relevancy in contemporary design education, but does not account for research-specific problem solving and ideation [25]. However, it is also argued that there is no such thing as a general design education [4]. Interdisciplinarity in design education is becoming a critical issue for design schools [26]. Design is not solely a practical skill that someone can be taught, but something one learns how to make [4]. Combining design principles with different disciplines can lead to better education and design outputs. Just as how other skillsets can lend themselves to design, design-thinking is also useful in entrepreneurship education and can also enhance cooperation with industry [27]. At an undergraduate, academic level, design courses may offer entrepreneurship modules to help position their design projects and aspirations accordingly [28]. However, there is a paucity of data in the literature relating to how potentially viable projects can be identified at an undergraduate level, scoped out, and taken forward to post-graduate research with the intention of developing IP and commercialising the design outputs in the form of a spinout company.

3 METHOD

Three case examples are presented from a research cluster which connects academics from Product Design and the Performance Arts in the area of music and dance. The research cluster was established through a funding award with a specific focus and expertise (Scientific and Technology Advisory Board STAB) but was specifically design-led to have the expertise required to realise product-based solutions. The cluster is made up of other disciplines as outlined in Figure 1. The cluster focus is aimed at developing innovative solutions that can address the needs of dancers and singers in the performance arts and health fields as this was an area that has been neglected in terms of product development.

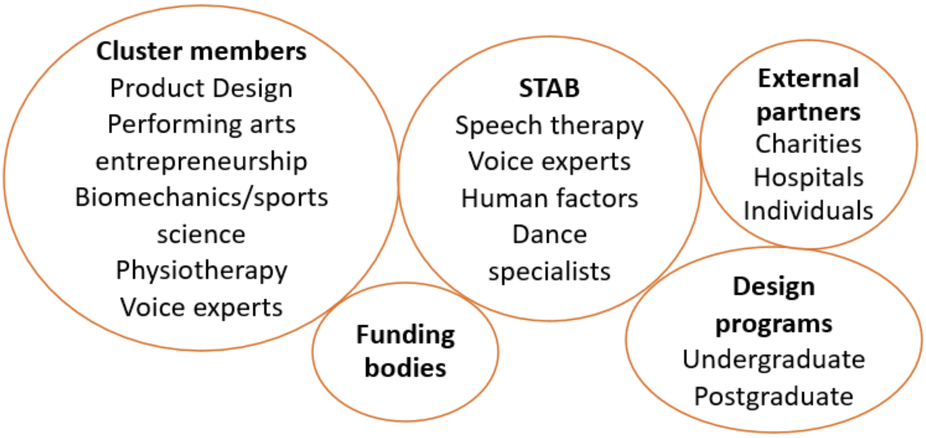

Figure 1. The cluster structure

While the cluster was funded by the institution, these funds were limited and inadequate to incubate more than one project. Therefore, the cluster relied on design programmes at both undergraduate and post graduate level to develop and incubate projects. Table 1 provides the detail of each project path. Figure 2 provides images from the three projects.

Table 1. Project descriptions

Project description	**Phase 1 delivery**	**Phase 2 delivery**
A design of a heavy Irish dancing shoe to mitigate against the injuries in Irish dancing. Project originator: Irish World Academy of Music and Dance -interfaculty collaboration.	6-week collaboration with four undergraduate Product Design students. Outputs: Early concepts with drawings and rough prototypes.	PhD project in progress. Studies completed: observations, interviews, and surveys to understand the needs of dancers. Video analysis of 28 dance steps to determine the biomechanics of the foot. Force plate testing.
The application of algometry to measure tissue sensitivity and pain perception. Project originator: Algotronics - external start-up company.	6-week collaboration with four undergraduate Product Design students to develop and test a soft padded garment to accurately house pressure sensors to record bio data. Outputs: developed concept through iterative drawings prototyping and testing.	Project completed at stage 1.
Device to support the health and performance of the vocal tracts of singers and those receiving voice therapy. Project originator: Final year undergraduate product design student.	Final year project at undergraduate level. Output: Qualitative research report with singers and singing teachers and a concept of a device to support singers applying the SOVT with prototype and cad drawings.	Project in 2nd phase with a researcher. Scope expanded to include speech and language therapy needs. The project has received the first stage of a commercialization fund to the value of €15,000.

Figure 2. The Irish dance shoe, Algometry, and Voice Health

4 FINDINGS

Table 2 describes the process undertaken by a small research cluster to incubate projects that can provide opportunities for innovation.

Table 2. The incubation process and selection criteria

1	Research cluster established through funding award with a specific focus and expertise (Scientific and Technology Advisory Board STAB) as per Figure 1.
2	Collaboration sought between external partners or other academic departments – School of Design and Irish world academy of Music and Dance.
	Project starts with undergraduate product design students with emphasis to the research and testing with stakeholders.
3	Project assessed and given red or green light to proceed to the next phase.
4	FYP student brings the project forward to a taught master's programme or is recruited as Research assistant to bring project to the next stage.
5	Collaboration with Technology Transfer Office (TTO) to file invention disclosures and file patents.
6	In conjunction with STAB and TTO apply for feasibility and commercialization funding.
7	Establish a spin out company or license the design to a company.

Several factors were used to rate the three projects to determine if they should proceed to the next stage of the process, see Table 3. All the projects progressed through Phase 1. However, only two of the three projects passed the screening to proceed to the next phase. Project 2 did not progress and failed on several criteria. The next stage of the project involved embedding sensors into the soft product that was designed in phase 1. It required the development of a working rig that included software and a working interface. Therefore, the scope was too great for the cluster, the expertise was not within the cluster, and there was not enough available time to seek external support. The cluster did not have sufficient resources to devote to the project and, as the partner was an external company, the cluster could not use its funding to develop the project further. The company also sought to retain the intellectual property rights.

Table 3. Rating criteria of the projects for stage development

Criteria for screening	**The Irish dance shoe**	**Algometry**	**Voice health**
Correct scope	Yes	No	Yes
Expertise	Yes	No	Yes
Time	Yes	No	Yes
Resources	Yes	No	Yes
Funding	Yes	No	Yes
Requirement for External Partners	No	Yes	No
Commercial Viability	Yes	Yes	Yes
Intellectual property (IP) potential	Yes	Yes	Yes
Intellectual property (IP) ownership	Yes	No	Yes

The success of the projects is contingent on several factors. Cluster oversight, access to experts and expertise across a variety of disciplines, access to research participants, access to key stakeholders for feedback and co-design, access to participants for testing, access to funding and IP ownership. It was also necessary to ensure a rewarding educational experience for the students involved.

5 DISCUSSION & CONCLUSION

Design programmes operate a studio-based learning model which is often time intensive for academics leaving them with limited time for research and practice. Our approach can enable academics to create a balance between teaching activity and research by combining both activities. The findings have shown that the incubation of solutions with commercial potential is possible through this approach while also providing a rich educational experience for students. A grass roots approach rooted in academic rigour, interdepartmental communication, and exposure to entrepreneurship principles at early-stage design projects leads to enhanced project outcomes and the generation of technically and financially feasible products for further development. Engaging with a project at undergraduate level allows for several projects to be explored and their potential developed without any capital investment. Promising projects may then secure funding for further development which can lead to commercialisation through spinout companies or industry partnerships. This approach is highly iterative, and through repeated testing and building, it is possible to meet the needs of the stakeholders. This approach can also allow for the development of refined prototypes that can be used to secure feasibility and commercialisation funding. The support of a STAB group and the TTO ensures that the right expertise is available at each stage of the project. The TTO can also relieve some of the workload for academics by supporting funding applications and intellectual property protection (IP). While working with industry partners is beneficial at many levels there are challenges around ownership of IP which in future collaborations would require upfront agreements put in place through contracts with each partner. As advocated by [1] our process is sustainable in that projects can be incubated to a stage without any significant costs. As not all projects have the potential for the marketplace, this also provides a supply of projects from which to select the most promising ones for commercialisation ensuring that projects that are put forward for funding are more likely to be successful.

This combined research and educational approach can also provide relevant industry linked experience for students as advocated in the literature [29, 30] where industry partners provide expertise and practical feedback as students work on projects with real world constraints. Cross disciplinary learning experiences have also been shown to enhance student’s learning experiences [26]. By combining teaching and research agendas this ensures that the educational experience for students is not given a secondary role to research as has been criticized in the literature [2] and that the pedagogical approach is up to date and relevant [1].

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