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Transferable Insights from Doblin's Model of Innovation

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Innovating Engineering Education at Greenfield Sites: Transferable Insights from Doblin's Model of Innovation

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***Abstract*—This Innovative Practice Full Paper explores the emergence of a number of innovative new models for engineering education around the world in recent years. These models offer valuable insights for the engineering education community; however, the transferability of these insights to established programs has been hampered by misconceptions around their contexts.**

Many of these new models have been established on greenfield sites that had not previously offered engineering degrees. The flexibility offered by working on a blank page has contributed to the success of these programs; however, it also fosters the misconception that this success is not transferrable to other institutions that already offer engineering degrees.

Examples of such programs are viewed through the lens of Doblin's Ten Types of Innovation. Launching a successful and sustainable new engineering program ultimately requires most, if not all, of the ten types of innovation at different stages of the implementation.

This paper will show the impact of the blank page context on the ten types of innovation. Some types of innovation (such as novel program structures) are made easier because of the absence of existing structures. This flexibility comes at the cost of greater difficulty in other types of innovation (such as implementing quality assurance) that comes from not having existing structures. Ultimately, the paper will show that the success of these programs is not due to their working on a blank page, but rather due to their adopting multiple dimensions from the Doblin framework, and their ability to adapt those innovations to the affordances offered by a greenfield environment.

We conclude by extending the model to show some examples of non-blank pages where substantial innovation has worked. The lessons demonstrated in the paper will guide engineering education innovators to focus on the kinds of innovation required, rather than the context in which they operate.

Keywords*—*innovation, Doblin, greenfield sites, engineering curricula, pedagogy

I. Introduction

Greenfield engineering education initiatives are those that have the advantage of being able to innovate as an autonomous entity from a parent educational institution. Greenfield projects can identify an unmet customer need and embark on a trajectory of exploiting that need in ways that established educational institutions have been unable to do.

It is significant to note that almost all of the institutions, identified by Graham in her 2018 report [1] as emerging leaders in engineering education, were greenfield sites, either creating new institutions that were primarily engineering in nature or introducing engineering to existing institutions that had not previously taught the discipline. This is in contrast with the identified world leaders, most of whom were well established large institutions that had disrupted as a part of continuous improvement processes.

These greenfield projects are free to innovate unhindered by legacy systems, processes and mindsets of established institutions. Working in a greenfield environment allows for innovation to be accelerated. They can start small, innovate, test, learn, adjust and continuously improve in a fast and efficient manner.

New programs and ideas can be developed without the "baggage" of existing habits and cultures. The price for this is that some of the "baggage" is actually "luggage" – useful practices that must, instead, be reinvented from scratch, rather than just simply applied through existing, supportive, work practices. This is the trade-off made by most start-up organizations, balancing the benefits of agility with those of scale. However, as presented in this paper, sensible and prudent use of existing innovations, networks and structures yields many advantages to the greenfield initiative.

Whilst greenfield programs are much more able to innovate in the structure and process dimensions, they do so at the cost of additional challenges to their brand and profit model. While these schools are free of the need to subsidize other colleges, or a research agenda, they also are not able to amortize governance and administrative costs across the balance of an institution.

This paper explores examples of greenfield programs through the lens of Doblin's Ten Types of Innovation [2], which provides a framework to better conceptualize these transformations. Jay Doblin established the Doblin consulting firm in 1981 on the premise that human-centered design could solve large scale business problems [3]. Doblin investigated this theory for many years and built the early framework for the Ten Types of innovation that is known today.

This paper will discuss some successful greenfield programs through the lens of their multi-Doblin innovation approaches, emphasising the nature of the innovation rather than the context in which it occurs. It will then explore a similar program operating on a brownfield site seeing internal transformations even in well-established programs. It will conclude by showing that it is the innovation, and in particular multi-Doblin innovation that matters, rather than the environment in which that innovation takes place.

II. Our Chosen Sites

This paper draws on three greenfield programs that have been recognised as exemplary new models of engineering education. These models all share a strong focus workplace learning and internships; as such a similarly industry-focused brownfield site has been chosen for comparison. The paper then considers one brownfield site, for comparison.

The CSU Engineering program (CSU) is a 5½ year integrated Master's degree [4]. It commences with three semesters of face-to-face Problem Based Learning, with Student Engineers (not engineering students) working on authentic, realistic projects. They then undertake four year-long paid placements in industry as Cadet engineers, solving real problems for real people for real dollars with real jeopardy, and evidencing their development through portfolios and theses. The underpinning technical content is delivered in three-hour modules online on-demand through a "Netflix-style" Topic Tree.

Iron Range Engineering (IRE) is a project-based learning model implemented in 2009 to meet regional industry needs for a technical workforce with a more work-ready engineer. IRE delivers two models: one is an on-campus team-based PBL solving problems FOR industry (inspired by Aalborg University [5]), the other is a co-op model solving problems while working IN industry (called the Bell model). Regardless of the modality a student engineer chooses, the curriculum and wide variety of innovative learning experiences are the same. In recent years, IRE received ABET's Innovation award and was recognized in Graham's 2018 report as an emerging world leader in engineering education.

The Rethinking Engineering Education in Ireland (REEdI) project at Munster Technological University (MTU) was successful in securing funding of €9 million from the Irish Higher Education Authority under the Human Capital Initiative Pillar 3 programme to deliver agility and innovation in Engineering Education [6]. The initiative is a quadruple helix collaboration between academia, industry, government and research centres. REEdI is a Greenfield initiative within an existing School of STEM, aligned to the current Department of Engineering at MTU. Therefore, whilst there was a blank canvas to develop the REEdI framework and associated programmes, this is not a Greenfield initiative like CSU or Bell and IRE. The first programme offered at MTU using the REEdI framework is a Bachelor of Engineering in Mechanical and Manufacturing Engineering (MME). The BEng in MME is comprised of two years on campus at MTU and two years in paid work placement at an industry partner while embedding the latest digital and immersive technologies.

UTS's Faculty of Engineering and Information Technology (FEIT) has 12,000 students across a range of undergraduate, postgraduate and research programs, so it's one of Australia's largest engineering Faculties. UTS has always had an applied view of education, tracing its history back to the Workingman's College in the 1870s. The UTS Model of Learning is built on three pillars (UTS, 2019): Integrated exposure to professional practice, Professional practice in a global workplace, and Research-inspired learning. In the last 6 years, FEIT has been transforming its engineering programs by introducing a sequence of studios to build professional competencies.

III. The Doblin Framework

When Doblin retired in 1986, Larry Keeley succeeded him at the helm of Doblin, continuing on Doblin's work into how to use the social sciences to solve business problems. It was not until 1997 that Doblin's Ten Types of innovation were identified, becoming a key enabler of innovation strategy. Over the coming years the Doblin consulting firm joined Monitor group and subsequently Deloitte LLC. In 2013, Keeley published the Ten Types of innovation, along with the key tools required to drive innovation [7].

Doblin's framework distinguishes three categories of innovation: **Configuration**, **Offering**, and **Experience** (**Error! Reference source not found.**). Configuration innovations include reconsidering the **profit model**, exploiting **networks** of suppliers, changing the **structure** of the organization, and finding superior **processes** for doing the work. Offering innovations include addressing **product performance** and developing complementary products and services to build a **product system**. Experience innovations include transforming the **services** that customers receive, the

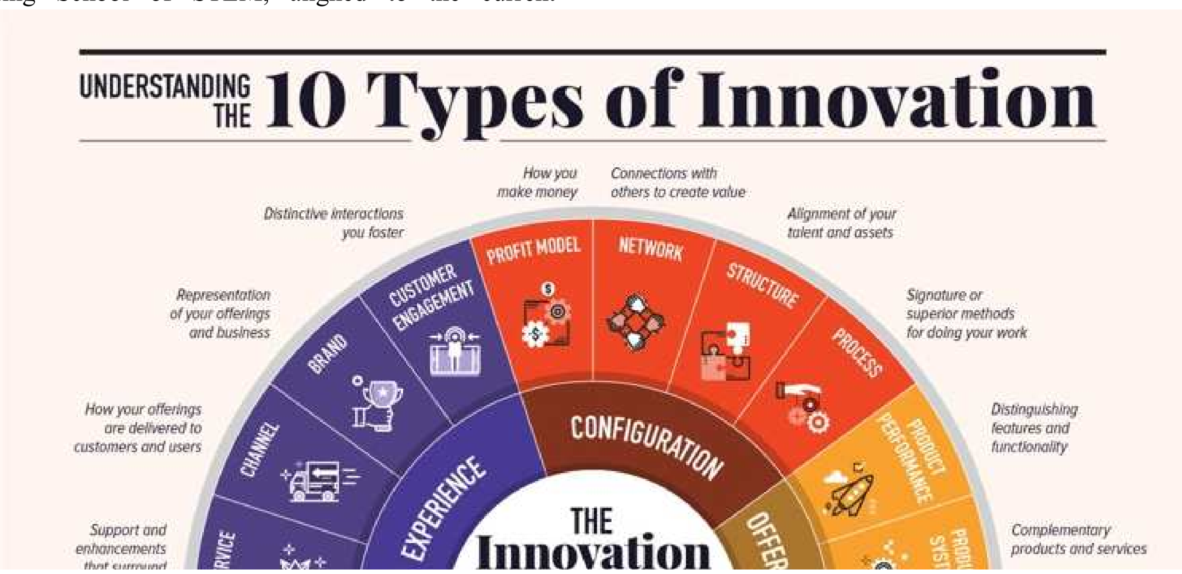

Figure 1: Doblin's 10 Types of Innovation [6]

channel through which the product or service is delivered, expanding the **brand**, and improving **customer engagement**.

There are more than 100 tactics, or prompts, that can be used to implement the 10 types of innovation [8].

In this paper, we use Doblin's lens to further investigate what yields this successful innovation in engineering education, an approach that has not previously been applied in engineering education research. We hypothesize that it is not necessarily the greenfield nature of a site that yields success it is the ability to identify and implement a multi-Doblin approach, where many or most of the 10 types must be considered in any successful transformation.

The identified greenfield programs in this paper exhibit this, albeit by retrospectively assessing and mapping their innovative aspects to the Doblin Framework. At first glance through Doblin's lens, innovations that appear (for example) to be a **network** innovation in these programs, may arguably be innovations in areas such as **channel**, **brand**, and **product performance**. These examples are presented and discussed throughout this paper.

Finally, Doblin's Ten Types of innovation have applications for not only greenfield sites but also for brownfield ones, as demonstrated by the UTS example. For future engineering education innovators, one can identify innovations in each of the three categories during the design phase of their greenfield initiatives. For current programs, Doblin's Ten Types of innovations can be used to assess current innovation activity to use a structured approach to drive future initiatives.

IV. Insights from Doblin

The Doblin framework offers a powerful lens to unpack the process of innovation in the product, which is an engineering degree. The naïve interpretation is that our innovations fall in the Product Performance category, developing a Superior Product that is "an offering of exceptional design, quality and/or experience".

While the overall offering of an engineering school may indeed be all of these things, when viewed through the Doblin lens, the overall offering of an engineering school is more than just the product; indeed, in many cases the unique selling point is in fact not the degree itself. The environment in which it is offered, the structures and processes that develop it, and the way in which it is experienced, all offer different dimensions for innovation – and it is along these dimensions that some of the most effective improvements to the "product" actually occur.

For external partners and potential students, the distinctions of the different Doblin dimensions ultimately do not matter. For those entrusted with the task of innovating and improving engineering degrees, however, the Doblin lens can be incredibly valuable in identifying areas for improvement – and it is often dimensions, other than Superior Product, where innovation can really shine.

There are some very successful examples of innovative models for engineering education [1]. One common feature of many of these programs is that they have been created on greenfield sites, either new institutions or established institutions that have not previously offered engineering degrees.

A corollary of this effect is that these programs have small intakes of students. An unfortunate consequence is that potential innovators, who do not have a greenfield environment, (mistakenly) believe that they cannot innovate – the "it would never work here" problem – or that the innovations can only work in small programs.

This paper will address the misconception that success comes from being a greenfield site. Success, in fact, comes from innovation that draws upon multiple dimensions of the Doblin framework and, while these dimensions certainly manifest differently in greenfield sites, they are still possible at large, well-established programs.

V. Focus: Graduates intended for industry

One of the key advantages of greenfield sites is that they afford clarity of purpose. A new program or school is a clear goal, with a fixed endpoint and outcome for those involved to focus upon. In the Doblin framework, this manifests as a **product performance** innovation – that of **Focus** [8]. The key simplification that runs through each of the programs identified in this paper is that they are designed to serve the single purpose of *producing high quality graduates for industry*.

Committing to a single mission provides a clarity of purpose to the programs identified in this paper; most powerfully it gives them the permission to then use the needs of industry-focused graduates as the primary design criteria in developing their programs.

While almost all anglophone engineering programs are accredited under the Washington Accord and, as such, should all produce industry capable graduates, the reality is that this is usually verified through compliance rather than used as a driving philosophy for program design. Engineering Schools are complex organisations, whose external metrics of success are often driven more by research key performance indicators; in these environments it is unsurprising that a potential pipeline of prospective PhD students is given at least as much importance in the design of programs . Entry to a graduate school requires a different set of skills and competencies than entry to professional practice; it is therefore not surprising that there are necessary compromises made to degrees in institutions where both objectives are being served. Where the programs identified in this paper differ is that they also use the clarity of purpose available at a greenfield site, as a driver of other types of innovation in the Doblin framework.

The clearest and cleanest of these flow on innovations comes in the area of **Brand**. Working from a greenfield site means that there is not an existing entity with its own reputation; rather, the new program is able to establish a brand (or sub-brand) for itself. In particular, the identified programs chose to commit to the Brand innovation of **Values Alignment**. Each developed a very clear sense of who they were as organisations, and what their values were and, as such, they were then able to project a clear sense of identity to potential students and industry partners.

These programs also have strong input from industry into their overall program standards, often sourced through formats such as workshops and surveys [6, 9]. While having program standards is not a major innovation *per se*, engaging closely with industry is a form of the **Product Performance** innovation of **Safety**. If your students know that their potential employers have contributed to designing the degree, it lowers the risk that the degree will not prepare graduates for practice.

The programs identified in this paper have also implemented strong co-op/internship programs, as a result of their close integration with industry. The additional workplace experience provided to the students can be seen as a form of the **Product System** innovation of **Product Bundling**. The access to cadet engineers for industry partners can also be seen as a form of the **Channel** innovation of **Cross-selling**.

The greenfield site adds complexity to the issue of establishing collaborations, which are a **Network** innovation. Working in a greenfield site means that the new organisation does not have pre-existing relationships with collaborators; this means that they have the challenge of establishing new relationships rather than the challenge of evolving existing ones. The external partners are all drawn to the clear purpose provided by the institution, and committed due to their explicit identification and match of values, but there is still the challenge of building new collaborations to deliver on these shared goals.

The identified institutions all mitigated this challenge by leveraging pre-existing relationships from prior environments. CSU Engineering used the existing CSU networks, and hired Engineers in Residence that also had connections. REEdI was similarly established from a consortium who already had a history of other partnerships. Iron Range was built upon the relationships between Itasca and the local Regional Development Board [10]. In these instances, the collaborations for the greenfield projects were new, but they were able to draw upon the trust established in prior relationships – they were not collaborations between strangers.

The greenfield nature of these sites also made the **Process** innovation of crowdsourcing more attractive. A clear goal of industry relevant graduates requires significant input from industry; the collective wisdom of the profession and the discipline has to be embedded into the degree. All identified programs engaged strongly with industry partners to support their cadetship programs, as well as in constituting their external advisory committees.

Overall, clarity of purpose goes beyond the product performance innovation of focus. It extends to the dimensions of **Brand, Network, Product Systems, Process** and even **Channel** – innovating in how the clear purpose is designed, articulated, and delivered.

VI. Porous Schools – Beyond Networking

The concept of a Porous School, where configuration innovations are designed and implemented to deliberately enable the flow of knowledge, people and technology, is made somewhat less tedious where there are no pre-existing constraints to work within. Engineering educators at a greenfield site can take Doblin's framework and innovate in a number of areas that are bucketed into the back end of the framework (**configuration**), areas such as **profit model, network, structure** and **process**. Such greenfield sites, in general, do not have the constraints of existing structures. For example, by being satellite programs, operating in a greenfield site, IRE is mostly exempt from the rigid structures and inertia often associated with university programs [11]. This allows **flexible manufacturing**, a **process** innovation, whereby there is the ability to rapidly react to changes while still operating efficiently.

In terms of driving the porous nature of greenfield sites, many funding bodies are acutely aware of the requirement to innovate in the **network** dimension and how important this back-end configuration setup is for later innovation possibilities. For this reason, we see funding agencies mandating strong networks as a key criterion for awarding funding to support some of the greenfield projects identified in this paper (REEdI [6], IRE [12]).

When we look at this concept of a Porous School, it initially appears that innovation here is primarily a **network** innovation within the back end of the pipeline. However, these **network** innovations, either by design or accident, systematically result in innovations in the **configuration**, **offering**, and **experience** dimensions and sub dimensions. We hypothesize that it is not necessarily the Greenfield nature of a site that yields success; it is the implementation of a multi-Doblin approach, with innovations flowing from the back-end networks established into other middle and front-end innovation dimensions. Examples of multi-Doblin innovations at the identified programmes are presented herein.

The identified greenfield programmes all exhibit strong innovations in the **network** dimension and sub dimensions by actively connecting with others in order to create value. The configuration elements of Doblin's innovation framework can be carefully curated behind the scenes to drive innovation from the beginning. However, it is important to note that how greenfield sites decide to set up their **configuration** will ultimately have a knock-on impact on later stages of the framework, the more "customer facing" front-end, where **customer experience** innovation is driven.

Essentially, how your organization and your products are configured and offered will determine how you can enhance your **customer experience**. The identified greenfield projects have worked with others outside of their organization to achieve these back-end network innovations. They have leveraged skills, expertise and connections to gain credibility, to enhance their products, processes and to ensure a broad range of technology innovations are embedded within their programmes.

The identified programmes actively worked to build **brand** innovation due to the embedded prestigious industry connections within their offering. The strong industry arm of the identified programmes innovates in the **customer engagement** dimension, with a focus on the **status and recognition** associated with the industry partners offering work placement, guest lecturing and mentoring opportunities for student engineers. The access to industry mentors innovates around the **crowd sourcing** dimension, whilst also innovating in terms of student/**customer engagement** and the students' sense of **community and belonging**.

CSU, IRE [13], REEdI and UTS [14] all leverage their strong networks to innovate in terms of industry project opportunities being available for students, whether on work placement or on campus. This deep-rooted innovation in the network dimension, results in **open innovation, collaboration** and **alliance generation**. The results of the **network** innovation arguably flow into the **product performance** dimension resulting in a **superior product** on offer to student engineers.

In addition, the opportunity for paid work placement as offered by CSU, REEdI and IRE [15] innovate in **product performance** and the **safety** sub dimension, as this removes the financial risk of embarking on an engineering degree for many students. The establishment of industry advisory groups or steering committees is another important network dimension innovation that results in innovations in other dimensions – **process, channel** and **brand**. The access to industry experts on an ongoing basis result in innovations in **strategic design** of the identified programmes, which industry champions actively promoting the programmes resulting in **indirect distribution, co-branding, brand leverage** and **values alignment**.

Both IRE and REEdI innovate in terms of the target market, which are often seen as **secondary markets** for other institutions. Both IRE and Bell are directed at the community college market, which can be seen as a **secondary market** in the U.S. REEdI does not only target school leavers (which would be seen as the primary market for most engineering degrees in Ireland), but is also directly attracting entrants (graduating apprentices) from Education and Training Boards (ETBs) programmes. This is also an innovation within the **Experience** dimension, offering a previously unavailable experience (REEdI has removed the requirement for advanced/ honours Mathematics as an entrance criterion), resulting in **experience enabling** for many learners who previously would not have gained entry to such courses.

At REEdI, student engineer access to the world class Science Foundation Ireland and Enterprise Ireland research centre **network** (CONFIRM, LERO, IMaR, ACE) affords a wealth of advantages in terms of exposure to cutting edge technologies and research staff across Ireland. This interlinking research network is key in ensuring that research innovations make their way into the REEdI MME programme, resulting in a **superior product** offering. Furthermore, REEdI, along with its industry partners, can identify research projects and apply (as a **supplementary and superior service**) for collaborative funding to conduct the research, resulting in a level of **safety** in terms of work-based projects and the generation of **intellectual property**. These projects provide valuable WBP project opportunities for REEdI Student engineers whilst also de-risking the WBP aspect for the industry partner. Similarly, with IRE, **intellectual property** is created during students work placement projects. Industry partners at IRE receive all IP created by students in exchange for their contribution of time and energy in the education process. Innovations around **service** are also seen in the CSU model. CSU Engineering established a consulting arm to provide expert technical capability to their region, resulting in a **supplementary** and **superior service**.

Whilst the greenfield sites have the blank canvas to establish their innermost workings, it is very much important to look to leverage existing **networks** and use these to foster further collaboration and forge new partnerships by extension to ensure multi-Doblin innovation across the framework. The combination of multiple innovations will produce more impactful and powerful results, particularly at greenfield sites. Conversely, brownfield sites can review their current configuration, offering and experience and use Doblin's ten types of innovation as a diagnostic tool to drive a multi-dimensional innovation strategy.

To reemphasize, the key is multi-dimensional innovation. We, as engineering educators, must innovate across multiple dimensions to drive successful innovation. We are not solely working to achieve a **superior product** (the engineering degree), we must ensure that our customers see the value in our offering [16]. This is where we must employ a multi-Doblin approach in order to innovate engineering education successfully.

In summary, stablishing a Porous School requires not only innovating in the **configuration** dimensions (network, structure, process) but also innovating across the **offering** dimensions (product performance and product system) and the **experience** dimensions (service, channel, brand, customer engagement) of Doblin's framework.

VII. Engagement

Engagement is multidimensional – students, staff, industry, and other stakeholders, need to be engaged. The Doblin model emphasises **customer engagement** as a key point of innovation. Students are easily seen as our customers and student engagement is a key part of all these greenfield programs.

Similarly, a key point of difference for these programs is the development of industry-ready graduates. In this sense, industry partners are customers for our products (our graduates). This willingness to engage, through internships and projects, ensures that there is a steady stream of students applying for entrance to the programs.

Industry partners are also an example of a **Process** innovation; it's a kind of crowdsourcing. Students become interns in a range of industry work placements, where their education continues, not through expert educators but through expert engineers. This fits Doblin's concept of **outsource** challenging work to a large group of semi-organised individuals [8]. This also has an impact on the **Profit Model**, because students do not need to be taught on campus, saving staff and space costs.

For students, active engagement in engineering activities develops identity as an engineer as a primary goal. This happens through language, program emphasis, learning strategies, and deep immersion in industry. At CSU and at IRE, students are referred to as student engineers, versus engineering students, recognizing that they are already in the profession, just in the student phase. IRE use a saying, "Become the engineer you want to be", with many opportunities for student choice and ownership, for example, student designed technical learning courses. This certainly provides student engineers with the autonomy and authority to use their study to shape their own experiences. This is a **Process** innovation as well as an **Engagement** one.

IRE has an established set of values and value statements: being a difference maker, reflection & self-awareness, self-directed learning, service & protection, inclusivity & professional courage. These values are burned into wood and posted in the hallways [10]. The infrastructure and processes of organizational design in these two programs flow directly from these core values. Learning strategies aimed at identity development are mostly focused through reflection in learning journals, specifically aimed at developing self-awareness and self-determination. This is a Structure innovation.

Student engineers are interfacing with industry clients from day one and ultimately immersed in industry for a substantial portion of their education. They develop their identity and engineering practitioners by practicing engineering alongside engineering professionals.

"During the IRE Bell Program I developed my technical skills through my classwork, and I quickly realized that my workplace represented another kind of classroom: one where I could grow professionally, as a leader and a teammate. " KH December 2021 Graduate

Technology is another tool, which fits the **Process** innovation (efficiency) category, as well as engagement. For example, the latest digital and immersive technology is used in the REEdI MME Degree to stimulate student engagement. Immersive technologies have numerous proven advantages in relation to education, including, enhanced engagement, increased knowledge retention, increased interest in content, increased motivation to learn, offering a safe environment in which to participate, inclusion and equal opportunities, improved subject understanding, increased grade performance, reduced insurance liability, and reduced requirements for physical space and equipment [17].

The REEdI Learning Experience Platform (LXP) is also a key **engagement** tool. The platform is set up to aid in adaptive learning, being a key tool for students and academic staff. The REEdI-LXP user interface (UI) is intuitive, interactive, and is highly visual. Its user-centred design includes elements of gamification. Research shows that gamification can be beneficial in motivating learners, building positive behaviour change, and facilitating engagement [18, 19].

Similarly, at CSU, the topic tree gives significant freedom in how students engage with the content [20]. This really has been an innovation of **Process**, transforming student learning to be just-in-time, rather than just-in-case, delivered asynchronously rather than synchronously. Students pick their own path though the content, rather than follow the typical fundamentals to elective path.

A unique feature of the REEdI MME Degree (compared to other Engineering programmes at MTU and indeed nationally in Ireland) is that student engineers will spend years three and four of the programme on work placement. At CSU, students spend four years on placement. This extended period of work placement reflects the requirements expressed by the programs' industry partners. This aspect of the program necessitated an evolution in the approach to teaching, learning, assessment, and engagement (TLAE) as the students move from the on-campus stage in years one and two to the work placement stage in years three and four (and five and six at CSU).

A key aspect in the design phase of the REEdI MME was a survey of the open engineering roles within the manufacturing sector in Ireland. This data was used by the curriculum development team to guide the design and development of module descriptors. One marketing strategy utilised by the team at REEdI, is to take this list of careers and develop "A day in the life" series of professionally curated promotional videos. These videos showcase each particular engineering role a REEdI graduate can pursue.

Peer mentoring and community interactions are another example of student **engagement**. The social connectedness of belonging to the profession, or identifying as an engineer early, leads to confidence and motivation attributes [21], which are of value as the student engineers in these programs, first exist in an industry-like atmosphere on campus, and then transition to work placements as part of the education.

From the **offering** perspective, REEdI and IRE include peers in the evaluation of each other. This can be seen as added functionality or as an integrated offering. By observing others' engineering practice, the student engineers get a broad exposure to both exemplars and failures of others. These opportunities bring a broader experience base for the individuals to bring to their own evaluations. Additionally, the individuals get the opportunity to deliver both positive and constructive feedback to peers. Normalizing this communication builds effective teaming skills.

Vertical integration of engineering teams provides collaboration, added value, and community/belonging, cutting across Doblin's **network, service,** and **customer engagement** domains. Rather than having teams of student engineers all at the same point in their education, vertical integration brings students from all levels together on a team, often including impending graduates with first term entrants. The experienced students share the organization's processes and expectations as well as stories from their own experienced successes and failures.

Deci and Ryan's self-determination theory of motivation [21] identifies three basic psychological needs that when each is met contributes to increased motivation and level of performance. Social connectedness is one of these needs. Peer mentoring through collaboration, community, belonging, and identity all bring social connection opportunities to the student engineer experience. Through their **structures, systems, and processes** these programs provide these added values.

CSU, REEdI, and IRE are work-based programs. Student engineers complete a substantial portion of their education while working as cadet engineers in industry, immersed in environments that include other co-op students from other universities and engineering professionals at various stages in their careers. Informal mentoring happens in these experiences. Further, structured mentoring happens as the programs have the students reflectively process and formally document their development.

The common theme seen throughout the analysis of programs through the lens of the Doblin Framework, is that multiple dimensions are present when innovation occurs. Peer mentoring in the on-campus portions and in the workplace portions of the education cuts across **configuration, offering** and **experience,** through **network, structure, process, product system, service, channel, brand, and customer engagement**.

Physical spaces are a key means to **engage** students at CSU. All CSU Engineers feel the sense of having a physical home that is theirs. This is an effect that is very hard to scale in an effective way to all students. There are certainly engineering schools that show the accreditation panel the maker space with room for 20 students and then tell them that all 1500 undergrads have access to it, so it's great, but it's not until you see something like Aalborg where they've actually given a space (table plus pinup boards) to every one of the 3500-odd student teams that you realise what a huge investment that kind of space is, and why it is so special if your institution can offer it.

One other dimension of **engagement** that can be considered is simply the fact that there is engagement with some of these students at all. Only about a quarter of the students accepted at CSU Engineering have an ATAR (Australian Tertiary Admission Rank) high enough to get accepted at a major city university, so there is possibly something to be said for the fact that quality experience can be delivered to a student cohort that wouldn't be accepted elsewhere, with such excellent success, as judged by industry partners. This widening of participation can also be considered a **Channel** innovation addressing **non-traditional channels**.

One final dimension of **engagement** concerns the academic staff. Changing a curriculum to be industry-focused and project-based brings engineering into the classroom – less learning textbooks (that are now online) and more solving complicated and complex problems. This appeals to the academics who see themselves as engineers first. Not only do they enjoy their work more, but they also discover that the students are way more talented than they thought they were.

However, there is a key step in academic engagement in an established university. Academics must be won over in the first place and, also, they need to develop the process skills for this new form of learning. At UTS, great success was found through Summer Studios, an innovation that transformed the process skills of students and academics [22].

Engagement is a key innovation in new curricula – engagement with students, academics, industry, and community. These examples show that engagement also links to process innovation in several ways, to structure, and also to the profit model, through outsourcing.

VIII. Multi-Doblin also works at brownfield sites: The Story at UTS

If you want to effect change in your organisation (intrapreneurship) you also need to touch multi dimensions. How does a large, traditional engineering school compare to these greenfield ventures? Are similar innovations able to be achieved at scale?

A. Porous School

UTS's Faculty of Engineering and Information Technology (FEIT) has 12,000 students across a range of undergraduate, postgraduate and research programs. UTS prides itself as a practice-led institution and the UTS Model of Learning is built on three pillars [23]:

1. Integrated exposure to professional practice
2. Professional practice in a global workplace
3. Research-inspired and integrated learning

FEIT enacts this practice-oriented approach in several ways, through industry advisory panels, through Australia's largest engineering internship program, through industry projects and studios, through guest lectures and presentations, and through industry-focused research programs.

The internship program has run for 50 years, and in its current form, students spend two, six-month placements in industry, usually in their second and fourth years of study. Many remain at their final placement and complete the remainder of their studies part-time, while working almost full-time. In this way, internships act as a simple recruitment strategy for many industry partners.

Since 2016, *studios* have become a key part of most programs, embedding a sequence of practice-oriented subjects, usually from semester two onwards. Many of these studios use industry-inspired or industry-led projects, where students work to create a solution to a current industry need. The Software Development Studios [24] led this shift in 2014, followed by the new Data Engineering program in 2017. Since then, more than 80 studio subjects have been created across the Faculty.

B. Purpose: Graduates intended for industry

FEIT maintains a balanced view of student destinations. There is clearly a focus on giving students a head-start in the workplace, through internships. In that sense, our graduates are intended for industry. Nevertheless, some students continue to a postgraduate degree (around 20% of our higher degree students have a UTS degree).

C. Engagement

At the heart of our push into studios is student **engagement**. One of our first, large scale experiments was Summer Studios in Jan-Feb 2018 [22]. At the start of the six-week intensive, students predicted that the best aspect would be gaining 6 credit points towards their degree! Halfway through, they realised the benefits that were accruing in terms of engaging in real projects, the first opportunity many had had. They then wanted more studios in their usual semesters. These studios were multi-age and multidiscipline.

One unexpected outcome of Summer Studios was the effect they had on the academics involved. For some, this was a lightbulb moment. They could see the level of engagement by the students and began to wonder how they might convert their usual subjects into a studio approach. This engagement of the academics has been critical in successfully rolling out the more than 80 studios that have been created since 2018.

There are several multiyear studios, e.g., where both fundamentals and application studio students work together (first to third year) or applications plus professional students (third to fifth year). This gives students some exposure to playing different roles in the team, sometimes a junior member and at other times, a senior member.

As a recommendation, providing an experimental space where an academic can try studio teaching with 15-20 students rather than 150-200 students, builds their confidence and eases the process of innovation across years and disciplines. Studios are, no longer, a teaching method to be avoided, but one that ids the default for many of our academic staff.

D. Summary

Transforming curricula requires innovation across the 10 Doblin types. At UTS, these have paralleled many of the dimensions used at the greenfield sites, through networking, curriculum structure, and process (configuration), through product performance and system (the offerings), and through service, channel, brand, and customer engagement (the experience).

IX. Conclusion

Recent years have seen the emergence of a number of new greenfield models for engineering education. These models have taken advantage of the opportunity afforded by a blank page to innovate in the way they offer their curriculum. The Doblin model of innovation allows us to unpack the offerings of these greenfield sites and to consider these offerings along the ten dimensions of the model. In doing so, it becomes clear that these greenfield models are innovating in much more than just the engineering degree. Rather, they are also innovating in the processes, structures, and environments of their respective engineering programs.

A detailed inspection of some of the emergent common themes shows that these programs are in fact innovating along all of Doblin's ten dimensions. By expanding their innovation beyond just the engineering degree as a product, these programs are able to create successful offerings that take advantage of process, experience, and brand.

Ultimately it is this comprehensive multi-dimensional innovation that has led to the success of these greenfield programs. While the nature of the greenfield site presents new opportunities and challenges that are not faced by established engineering programs, it is how these programs have responded to those opportunities and challenges that matters, not the nature of the context itself.

This paper has provided a comparable established program that is also undertaking multi-dimensional innovation, and has shown that similar outcomes are possible. In doing so, it further emphasises that it is the nature of the innovations that matter, rather than the operating context.

The Doblin innovation model provides a useful lens for considering the development of engineering degrees. It provides insights into the way in which greenfield sites can support innovation in engineering education, and it provides potential guidance to engineering educators who may also seek to improve their programs, however well-established they may be.

X. References

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