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The magic of partnering with students to create transdisciplinary STEM curricula

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ABSTRACT

CONTEXT

Co-creation of curriculum with a range of different partners is an increasing practice of learning and teaching in the higher education sector. In research, partnership models for collaboration with a range of stakeholders, notably industry, are well established and practiced, but fewer models exist that show how to partner in teaching. The growing success stories of curriculum co-creation with student partners show that partnering with students is a practical and a sustainable way to create engaging curricula. A benefit is that student outcomes and desires often align with institutional aims such as producing capable and confident graduates that can work in any industry beyond geographical and disciplinary constraints. This contrasts with industry partners who are often interested in job ready graduates for the specific industry or sector. In this study we are presenting our learnings from partnering with students in designing transdisciplinary curricula.

PURPOSE

The aim was to design minors that attract and encourage students from non-STEM backgrounds to use their elective space to study curriculum that helps them to develop STEM capabilities. This aim is in line with training job ready graduates and strategies to address National Priorities and Industry Linkage Fund (NPILF). The minors were designed in consultation and collaboration with industry partners and academics from different disciplines.

APPROACH

Two minors were designed by choosing subjects from four different disciplines and a capstone project was added to create a hands-on learning opportunity for students. Subjects were chosen from four different schools to ensure the trans-disciplinarity aspect of the design. The most important criterion for subjects included in a minor was the lack of restrictive prerequisites to ensure that all students could enrol.

OUTCOMES

Collaboration with Industry allowed us to implement development of STEM skills or capabilities as the learning outcome, but collaboration with students was instrumental in designing curricula that was attractive to students and relevant to the future generation of graduates. Therefore, students were embedded in the process of design of these minors all the way from ideation to marketing the curricula.

Minors were built around two topics of *health* and *sustainability* that a) students found interesting and b) where industry indicated there were current and future job opportunities. The curriculum design was fine-tuned following several discussions with student partners and surveying a larger group of students. In consultation with subject coordinators the student partners critically evaluated the assessments in each of the subjects to ensure that students from diverse disciplinary backgrounds would be able to complete the subject. The minors were presented to a larger group of students before presenting them to various academic committees for approval. In addition to

developing traditional resources such as the handbook entry, marketing videos were produced by student partners to communicate the new curricula to incoming students. "*Innovating For Humans*" and *"Eco-Socially Conscious Design & Manufacturing"* were offered in the first academic session of 2022.

CONCLUSIONS

Designing trans- multi or interdisciplinary, curricula ***is not*** just bringing subjects with no prerequisites from different disciplines around a core topic. It is vital to ensure that the subjects are indeed linked by a common theme, but that learning outcomes are scaffolded and achievable and that the subjects can be completed *successfully* by students from all disciplines. We soon discovered that learning guides were not the most reliable source of information and going through the learning activities and assessments with student partners and unit coordinators was essential to identify the hidden assumed knowledge and disciplinary focused skills. Subsequently, learning activities and assessment of some subjects were revised and the unit coordinators designed extra resources and supports to assist students from other disciplines. This process also benefits students from within the discipline.

As STEM educators we did not anticipate that the biggest challenge of designing transdisciplinary curricula in STEM was to get the right level of STEM content to achieve the intended learning outcomes while keeping them attractive to students from other disciplines that were raised in an education system that presented STEM as a "difficult subject".

The outcome and process of this curriculum development work would have been very different without collaboration with student partners from different disciplines. Working with students was a great learning experience that can be described as designing a product for the end users *with* them and eliminating assumptions and predictions. Although this work was on designing interdisciplinary curricula, we believe this model is an efficient strategy that can be applied in designing of engaging discipline focused curriculum.

KEYWORDS

Transdisciplinary curriculum, STEM curriculum, Co-design, Partnership.

Introduction

> *Partnership Pedagogy means a key concept shaping curriculum transformation at the University. It refers to curriculum that is co-created with a range of internal and external partners – community, industry, our commercial providers, our Research Institutes, and our students. (WSU Policy Statement)*

The quote above is taken from the curriculum design policy at our institution (Western Sydney University, WSU) and illustrates how the involvement of partners in the development or redevelopment of curriculum is recognised as not just important, but essential. (Peseta, Bell et al., 2016) WSU is not alone as most higher education institutions will have some recognition that partnership pedagogy, which involves working together with students, industry, government and/or community organisations, can help to generate curricula that is authentic, engaging and robust as well as being relevant to the future work destinations of graduates. Partnership pedagogy relates to the intentional inclusion of alternative (to academics) voices and opinions in the design of curriculum and can include any, or all, of the 'four co-s': co-design, co-development, co-delivery or co-assessment. (Barrie and Pizzica, 2019) Whilst partnership pedagogy can refer to a diverse range of possible partners, it is partnership with students that has the potential to be transformative for academics and students alike. Student-staff partnership (or Students as Partners, SaP) is one in which there is the 'opportunity to contribute equally…to curricular or pedagogical conceptualisation, decision making, implementation, investigation or analysis'. (Cook-Sather, Bovill et al., 2014) Despite only recently being integrated into institutional policy (at least at WSU) it is not a new concept and there are many examples describing the variety of learning and teaching projects that have included students. (Bovill, 2019) In this paper we present a case study of curriculum design in STEM (Science, Technology, Engineering and Mathematics) that included many different partners, but here we focus on the role the student partners played.

Context

The future of work that new graduates face is one of increasing complexity driven largely by technological changes. These changes have already seen many traditional jobs lost due to automation and it is likely that every type of career will be impacted by technology. Indeed it is thought that future workers will spend more than twice as much time on tasks requiring science and maths than they currently do.(Department of Education, 2021) This will hold true irrespective of the job and it is unlikely that any career will be immune to technologically-based disruption. In order to successfully face these challenges new graduates need to be equipped with skills that can support them in traversing the changing world of work. Whilst these skills do include generic competency such as complex-problem solving, critical thinking and working with others ('21st Century skills'), they also include STEM-based skills and capabilities that provide graduates the capacity to contribute successfully to a technologically advanced workplace.

One approach that can help develop the kind of skills and thinking required beyond graduation is to allow students to move beyond the traditional discipline structure encountered in many institutions. Whilst few would argue that it is necessary in the STEM fields to have a strong disciplinary core, having only their discipline to support them may lead to graduates that lack the creativity or knowledge required to address challenges in future careers and society. Concepts based on interdisciplinary and multidisciplinary can lead to education that encourages students to recognise, synthesise and integrate links between disciplines, whilst retaining disciplinary boundaries (*multidisciplinary*) or blurring those boundaries (*interdisciplinary*). (Choi and Pak, 2006) Transdisciplinary approaches try to remove disciplinary boundaries in order to deal with complex, or 'wicked' problems and where the outcome has no disciplinary preconception, i.e., the solution may not represent any disciplines initially involved. (Scholz and Steiner, 2015) A good analogy presented by Choi and Pac (2006) suggested transdisciplinarity is 'like a cake...in which the ingredients are no longer distinguishable, and the final product is of a different kind from the initial ingredients'. Further scholars have added to transdisciplinarity to generate convergent education which not only removes disciplinary boundaries, but includes other knowledge types and stakeholders (e.g. industry, government and non-government organisations) in order to solve contemporary challenges and to rapidly translate the resulting advances.(Herr, Akbar *et al.*, 2019)

Case Study – A curriculum to build STEM capabilities

To equip all students for success in a disrupted future of work and society, and to help contribute to the university fulfilling its obligations under the NPILF the goal of this project was to design curriculum (a minor) that would be available to any student in the university (i.e. taken as an elective). The minor needed to align with NPILF priorities, *viz*. development of 'STEM-skilled graduates' which are considered to be skills expected to be gained from tertiary-education subjects of STEM and covers both broad education in discipline content as well as the scientific method. (Department of Education, 2020)To align with the goals of transdisciplinarity, the minor needed to be comprised of at least five subjects derived from four different schools (i.e., disciplines) in the university (to claim the minor students need only complete four of the five subjects offered). A constraint was that no new subjects could be made, the minor had to be built from subjects already existing. To promote STEM capabilities the minor needed a STEM-based 'capstone' subject that incorporated work-integrated learning activities to allow students to experience and apply their skills in a STEM setting. Overall, two minors needed to be delivered.

Importantly, the case study described in this work was chosen because the principles of partnership pedagogy described above needed to be followed in designing the curriculum. Alongside the 'curriculum champions' nominated to lead the project (i.e., the authors MD and CEJ), partners included Industry representatives, academic mentors, students and curriculum fellows (Figure 1). Whilst all of these partners were important to the conception, design, development and, in some cases, delivery, of the curriculum, alongside the curriculum champions only the student partners were present from ideation to completion of the project. In Engineering and arguably all STEM disciplines co-design with industry is relatively common but co-design of curricula with students is rare. The case study reported here is one of the first at our institution in which students were actively recruited to participate in the design and development of new curricula.

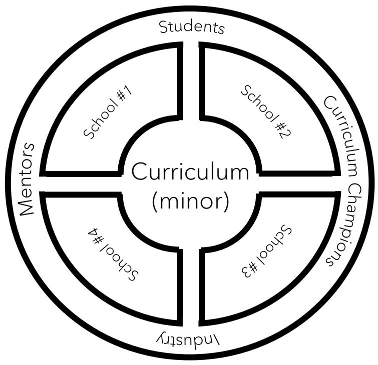

Figure 1. The curricula (minors) were developed using subjects from four different disciplines (schools in the university) and utilised partnership pedagogy with a diverse range of partners (outer ring).

Students as partners in the curriculum build.

The overriding goals for the curriculum build was to develop minors that could be taken by any student in the university and develop some STEM capabilities. The approach to curriculum design followed Biggs' idea of 'constructive alignment', where the broad topics, aims and learning outcomes of the minors were developed before delving into assessments. (Biggs, 1996) Even though a restriction was that no new subjects could be developed, and thus no new assessments, alignment of existing assessments with the new intended learning outcomes for the course (minor) was an important aspect in the design. While the curriculum champions (project leads) were STEM teaching and research academics from the schools of Science and Engineering, Design and the Built Environment, the student partners came from several different disciplinary backgrounds. Over the year-long project the four undergraduate students who were involved came from Law, Arts and Design, Medical Science and Secondary Teaching disciplines and all but one were in their final year of their degree. These students were from a larger group of paid Student Curriculum Partners involved in a broader program of curriculum transformation and were supported by an academic staff member experienced in partnership pedagogy. (Peseta, Donoghue *et al.*, 2021) Thus the student partners came to the project with some reasonable idea of what partnership pedagogy could look like in practice, in contrast to the two curriculum champions who had been involved in partnerships in a research capacity but not in curriculum development.

Student partners were involved from the very beginning of the project and their co-creation of the minors largely followed what has been described as co-creation *of* the curriculum (students co-designing a course to be offered in the future) before moving to co-creation *in* the curriculum (e.g., reviewing teaching and learning materials within the course). (Bovill and Woolmer, 2019, Baumber, Kligyte *et al.*, 2021) In line with the concepts of transdisciplinarity, co-creation of the curriculum involved identification of a contemporary, complex topic on which to build the minor around followed by searching all subjects offered by the university to find at least five that addressed some aspect of the topic. This then lead to students co-creating course learning outcomes and preparing the documentation required for ushering the course through the university approval processes. An example of co-creation in the curriculum involved student partners examining learning materials (i.e., learning guides) to ensure that the chosen subjects were able to be understood, and successfully completed, by an enrolled student irrespective of their disciplinary background. The students then worked with the subject coordinators to revise the learning guides. Overall, students offered their voice (offering opinion, feedback and advice) as well as their contemporary skills learnt from concurrently doing subjects in their degrees.

Outcomes and Discussion

The main outcome of the project was the delivery of two minors centred around topics of sustainable manufacturing (Table 1, Minor 1) and technology and health (Table 1, Minor 2). The minors were first offered to students in March 2022. We report here on the experience of designing the minors and the role that student partners had in the process. Judgement about the extent to which the minors achieve the desired learning outcomes awaits feedback from enrolled students and will be reported in the future. Subjects that were used in the minors came from disciplines (schools) as shown in Table 2.

Table 2. Disciplines represented in each minor.

Disciplines in Minor 1 Eco-Socially Conscious Design and Manufacturing	Disciplines in Minor 2 Innovating for Humans
Science	Education
Psychology	Health Science
Engineering, Design and Built Environment	Computer, Data and Mathematical Science
Business	Engineering, Design and Built Environment
Engineering, Design and Built Environment	Science

The minors were intentionally designed to provide any student with the opportunity to experience subjects that were outside their discipline and to develop STEM capabilities. Searching through subjects on offer at the university followed by critical appraisal of learning materials and interviews with subject coordinators allowed the curriculum champions and SaP to identify appropriate subjects. These subjects were those that did not have overly restrictive prerequisties which was necessary to allow students to take the subject as an elective even if it was outside their discipline. Furthermore, subjects needed to have a learning outcome or activity that aligned with STEM capabilities. These capabilities revolved more around STEM thinking rather than specific STEM skills (e.g., laboratory-based skills) and focused on capabilities such as hypothesis-driven inquiry and the role of evidence in critical thinking and decision making. (Jang, 2016) Interestingly, the number of subjects outside of the traditional STEM courses that could be considered as teaching STEM-type capabilities was significantly greater than we previously appreciated. The student partners were critical to ensuring that the subjects chosen were interesting to non-STEM students as this was the cohort that was targeted. In this aspect their non-STEM background was very important as it allowed them to recognise where and when the STEM content was too onerous. Nevertheless, the minors contained multiple subjects from the schools of Science and Engineering, Design and the Built Environment, with one from each school chosen as a ‘capstone’ WIL-like experience that allows students to work in multidisciplinary teams on specific STEM projects. Opening up these project-based subjects to students outside STEM will allow the goals of transdisciplinarity to be more readily achieved because not only will non-STEM students apply STEM capabilities learnt in previous subjects in the minor, but will also allow the STEM students taking the subjects to be exposed to thinking and language they perhaps do not readily encounter within their disciplinary degrees (i.e. from students outside STEM). In this regard the ‘capstone’ experience provided in these minors are a close representation of the multidisciplinary workplaces new graduates will likely face in the future.

There has been significant discussion in the SaP literature surrounding the power relationships in such partnerships. In this project those relationships still existed, however were muted for several reasons. The necessity of designing curricula using subjects from multiple disciplines meant that no team member, including the curriculum champions, were subject experts. The curriculum champions, as project leads, could not claim expertise as their disciplinary expertise was of no particular relevance in this project. Any preconceptions the academic leads had regarding how the minors would look were quickly lost once the student partners were engaged. Further, the curriculum champions were naïve in partnering with students, whereas the students came to the project with background academic support who help them to have some understanding of their role. The ‘magic’ referred to in the title of this paper, relates to the idea that academics can design curricula following a recipe that has preconceived ideas of what ‘students should learn’. However, by including students and recognising the expertise and knowledge they have of not just the university but also their broader experience as contemporary students, the outcomes of any curriculum build are not predetermined and can be quite different to what academics might have expected. Indeed, a key learning for the curriculum champions in this project was that to benefit from SaP projects academics need to actively relinquish power to the students and genuinely engage in a ‘collaborative space wherein individuals work together, beyond the confines of their institutional roles’. (Matthews, Dwyer *et al.*, 2018) Overall, the involvement of SaP in this project has lead to the development of minors that will allow any student to gain some STEM capabilities, whilst also being interesting, engaging and, importantly, able to be successfully completed by non-STEM students.

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