Chapter 9.

Internationalisation of the Curriculum in Higher Education as a Catalyst to STEAM

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Introduction

Ours are times of paradox and change. We have reached a stage in which science and technology have on the one hand enabled us to live longer, provided us with instant global communication, and revolutionised production to include robotics and automation— and with this, the possibility of a radically different future. But on the other hand, the rapid increase in population and the same positive developments just outlined mean this is the first human generation whose actions will flood low-lying islands, whose rate of resource consumption is well above two and a half times the production capacity of the planet, and whose supply of drinkable water and clean air to breath are not guaranteed (Brown, Deane, et al. 2010, 3-5). Issues such as these, and climate change, global health, urban violence or coping with biodiversity loss are all examples of 'wicked problems', that is, problems for which there can be no final solution since they are part of the society that generates them, and any changes to the situation introduce further issues. Our incapacity to address wicked problems has been traced to the compartmentalization of scientific and professional knowledge, to the sector-based division of responsibility in contemporary society, and to the increasingly diverse nature of the social contexts in which people now live (Lawrence 2010, 16). Transdisciplinary research[1] and practices offer an avenue for the STEM disciplines, the arts, humanities and social sciences (STEAM) to overcome these obstacles and tackle these truly vital issues. It also introduces a model of accountability to society, and promotes innovation as previously separate fields are brought in contact with one another. Transdisciplinary models of knowledge production are a necessary response to demands that academic life becomes more integrated with society and the economy. At any rate, it is estimated that each day we generate the knowledge contained in all the world's libraries, so transdisciplinarity may well be the only sustainable way forward as regards the production and

[1] Although it is common to understand multidisciplinary research as that which draws from various disciplines, each bringing a contribution towards the resolution of a problem; interdisciplinary research as that in which synthesis occurs; and transdisciplinary research as that which frames the question 'as part of a total system without any firm boundaries between the disciplines' (Barry and Born 2013, p9), here I take the term to mean the collective understanding of an issue created 'by including the personal, the local and the strategic, as well as specialised contributions to knowledge' (Brown, Deane, et al. 2010 p. 4), which goes beyond academic knowledge.

application of knowledge: 'the world is more ecological than we had thought […] rather than it being possible to study phenomena in isolation, everything is implicated with everything else […] life is lived in media res' (Frodeman, Thompson and Mitcham 2012, xxx-xxxiv).

Importantly, all the wicked problems mentioned above are global in nature and require a global citizenship mind set to be addressed. But culturally, the world has become increasingly more divided as it has become more connected, and there is an urgent need to build bridges of tolerance and respect through education. International interaction and collaboration through education can foster cross-cultural insight and exchange that is enriching and enabling 'for individuals, communities, nations and the world' (Leask 2015, 17), and potentially as useful to pool towards the resolution of our most pressing issues as the disciplinary knowledge. Universities have attempted to face this challenge with Internationalisation of the Curriculum (IoC) and Internationalisation at Home (IaH) initiatives. Briefly, IoC entails the incorporation of 'an intercultural dimension into the content of the curriculum as well as the teaching and learning processes and support services of a programme of study' (Leask 2015), while IaH, a subset, is defined as 'any international activity with the exception of outbound student and staff mobility' (Green and Whitsed 2015, 7).

Thus transdisciplinarity, especially in its STEAM variety, seeks to respond to our common human challenges through the integration of science, arts and humanities. And internationalisation efforts seek to provide a fuller, more rounded education to individuals by integrating knowledge produced in different cultures. Both approaches share the need to transcend cultural boundaries, the one from disciplines, the other from national cultures, and both from the institutional contexts in which higher education is embedded. Importantly, both ascribe a central role to imagination, normally associated primarily with the arts. Transdisciplinary perspectives recognise that 'leaps of creativity in the formalised science are exemplified in the classification of life forms by Linnaeus, which differed significantly from those of Aristotle before him and Darwin after him […] For each inquiry across the ages, a flight of the imagination led to fresh scientific concepts and images which changed the interpretation of reality' (Brown, Deane, et al. 2010, 9), whereas the key difference between the internationalisation of the curriculum process and commonly used curriculum review cycles is 'stage two, the imagine stage. It is essential and integral. It stimulates creative uncertainty through challenging the traditional and taken for granted […] and inviting broadening and deepening of engagement with difference' (Leask 2015, 42). And notably, both entail considerable personal, even transformational change. STEAM values the capacity to be flexible and adapt in teaching and research: 'under the shadow of the mindless repetition of old lectures and the artificial extension of exhausted research programmes' the ability to undertake transdisciplinary research 'is seen as a mark of flexibility and adaptiveness, which are highly valued in today's knowledge economy' (Graff 2015, 2). From the perspective of graduate employability, it has even been argued that the 'skills' framework of reference that has been so central in the literature be modified for a focus, after Pierre Bourdieu, on capitals: human capital (the hard skills and

technical knowledge), social capital (that which creates a bridge between graduates' educational experience and helps them broker their access to job openings), identity capital (when graduates harness their sense of personal identity around targeted employment, including channelling existing lifestyle and extracurricular activities towards that goal), and psychological capital, i.e. levels of resilience and adaptability (Tomlinson 2017, 18), very highly valued and promoted by holistic approaches such as STEAM. And IoC theories speak of the internationalisation of the academic Self. Understanding one's own linguistic, socio-cultural, political, ethical and educational constructs, values and beliefs, as well as the process whereby they were formed though enculturation 'has continuous relevance in the ongoing project of intercultural teaching and learning across curriculum that aspires to "internationalisation" ' (Green and Whitsed 2015, 10). As put by Green and Whitsed, if the ideal graduate is interculturally sensitive and competent, a socially responsible and globally aware citizen, then the ideal lecturer in the present context is one that broadens curricula and incorporates pedagogical approaches (p. 10).

However, despite all this fundamental common ground between STEAM approaches and IoC and their radical ambitions, so far IoC has been pursued exclusively around disciplines. This may be because like the national cultures that IoC seeks to draw from, the disciplines have been perceived as different cultures, at best as 'separate communities of practice with their own organisations, power hierarchies, questions to answer and [sometimes heavily policed] entry boundaries' (Brown and Harris 2014, 115), if not as 'artificial holding patterns of enquiry' with metaphysical significance that cannot be overestimated, according to Steve Fuller (quoted in Graff 2). Still, IoC takes it as given that

> Disciplinarity exerts enormous power and influence over the organization and production of knowledge and discipline groups are global communities […] Discipline communities transcend national boundaries. They provide an organizational focus for universities and the curriculum across the world. They are at the heart of the process of IoC (Leask 2013, 99).

In the paragraphs that follow I propose an alternative view of IoC, as an ideal enterprise to pursue STEAM agendas, for as I have shown the two in fact overlap to a large extent. Inasmuch as IoC seeks to develop students' international and intercultural perspectives as global professionals and citizens, it calls for engagement with the arts, humanities, social sciences and sustainability initiatives across programmes. Moreover, even the 'hardest'[2] and purest natural sciences are taught, and teaching is always a socially constructed activity (Carroll 2015, 104), thus any IoC in science must by necessity engage education and other humanities. Where

[2] A much utilised taxonomy of knowledge that classifies disciplines as hard science (mathematics, physics), hard applied (medicine, civil engineering, pharmacy etc), soft applied (psychology, law, business and economics) and soft (art, design, history, media studies), has found the last 3 far more open to IoC.

relevant I illustrate with examples from the experience with IoC and STEAM at University College Cork, Ireland.

Internationalising the Curriculum for STEAM

Essentially, internationalising the curriculum is a form of Critical Participatory Action Research in which teams of academics responsible for the curriculum at the programme—or occasionally course—level actively enquire into their own teaching practice and their students' learning process to inform their understanding and make improvement in order to achieve the following learning outcomes:

1. Global Perspectives. IoC demands knowledge of other countries and cultures and competence in other languages. One way to promote STEAM would be to include computer programming languages in the options available to all students (Denicolo 2013, 53).
2. Intercultural competence. Sensitivity to the perspectives of others and a willingness to put oneself in their shoes. An understanding of the nature of racism. This intercultural competence can also be promoted by requiring students to frame a problem from an arts and humanities, or scientific perspective accordingly.
3. Responsible global citizenship. Understanding the necessity to engage with sustainability, equity and social justice. This learning outcome is a shared goal of STEAM.

IoC considers the curriculum both as formal, comprising the syllabus as well as the organised experiences that are part of a student's programme of study, and informal, consisting of the support services and additional activities available on campus. In addition, the 'hidden curriculum' is taken to mean the unintended and implicit messages of whose knowledge is valued and indeed what counts as knowledge, since every selection implies an omission—for instance, although the IoC perspective considers indigenous knowledge, in contexts in which science is taught, art can often be perceived as knowledge that is less valued. Together they make up the total student experience, and rather than being separate and discrete, the three overlap to some extent. At all these levels, and in particular in the area where they overlap, opportunities are provided for interventions that seek to attain the above learning outcomes.

As mentioned above, the IoC framework puts the disciplines at heart since they define the scope of the curriculum. They are constrained by institutional, local, national and global contexts, and must engage dominant and emergent paradigms. Requirements of professionalism and practice, assessment, and the need for systemic development also contextualise and constrain the curriculum (Leask 2015, 27). But to internationalise the curriculum for STEAM, recent changes in the role of the disciplines in universities must be taken into consideration. Paul Trowler contends disciplines are undergoing significant transformations due to the impact of global and domestic market forces, casualization of the academic workforce, the

amalgamation of departments into single units, or their closure (Trowler 2012). Wendy Green and Craig Whitsed also note the growth of interdisciplinary 'domain based' studies, such as 'women's studies' or 'environmental studies', resulting in disciplines being reconfigured as spaces of polyvocality where multiple, conflicting narratives co-exist (2015 280). Further, they offer a useful metaphor to conceptualise this change in which the former regime of production of academic knowledge in universities could be described as analogous to a chess game: a closed space of territorialisation with each piece, the disciplines, coded with a pre-determined hierarchy and organised according to its function. The present regime is by contrast similar to a Go! Game in which pellets are situationally defined, movement is relatively free and pieces operate in open space where power is fluid. As the game is being played, the identity of any given disk changes in relation to other disks, so they are always in a process of becoming (p. 281-2). Indeed, their research entitled 'Critical Perspectives on Internationalising the Curriculum in the Disciplines' actually reports numerous similarities in the challenges faced by a variety of disciplines, while also intradisciplinary differences. They conclude that IoC 'necessitates the development of critical interdisciplinary spaces which foster the exchange of innovative ideas' (p. 280). By the same token, Harvey Graff notes that we easily assume differences between disciplines and interdisciplines rather than relationships and connections, and that the focus tends to be on the addition of disciplines rather than their interactions (Graff 2015, 6). Even Betty Leask, who at one point characterises the disciplines as 'the life-blood of higher education, providing both an organisational focus for the university and the curriculum and a social framework' (p. 28) later admits that 'it can be an advantage to encourage interdisciplinary conversations and debates' while internationalising the curriculum as 'this can be an effective way to stop the censorship that is often practiced by discipline communities on their colleagues' (p. 110). In sum, from epistemological reasons on the nature of knowledge in the present context, to the practical business of discussing how to internationalise the curriculum in a given programme, a transdisciplinary approach that puts STEAM at its heart is better suited and can be more effective to pursue IoC.

IoC should be a volunteered process, undertaken with an open mind and in diverse groups. The planning team thus bring their disciplinary strengths, past experiences, cultural backgrounds and skills, all of which are also useful to consider, including a transdisicplinary outlook. The process starts by identifying and seeking to maximise programme level opportunities and benefits. As all sound policy design, it should look forward and prioritise values and outcomes, aiming for transformation: of the curriculum, concepts, students and ultimately university communities (Carroll 2015, 105). It is iterative, linking together decisions about design, teaching and assessment and making connections between them explicit. It consists of five steps, namely review and reflection, imagining, revision and planning, action and evaluation. The questionnaire on internationalisation of the curriculum or QIC is an often-employed tool, which stimulates reflection and guides the discussion. Below I list the main steps drawing from Leask 2015 41-50, adding the way in which the same step can be used to embed STEAM in the curriculum at the same time.

Table 1. The IoC Process (Leask 2015) revised for STEAM

Step	For IoC	For STEAM
Review and Reflect	Establishing a rationale: what international/ intercultural knowledge, skills and attitudes will students need as graduates of the programme?	Establishing a rationale: what interdisciplinary knowledge, skills and attitudes will students need as graduates?
	Review content, teaching and learning arrangements and assessment, identifying opportunities to develop the skills/ attitudes or introduced the knowledge deemed as essential	
	Reviewing student feedback for strengths and weaknesses in relation to internationalisation	Reviewing student feedback for strengths and weaknesses in relation to inter/transdisciplinarity
	Comparing and contrasting feedback from international students	Comparing and contrasting feedback from students from other programmes in different colleges
	Reviewing feedback of other stakeholders, such as industry partners and professional associations	
	Reviewing institutional goals in relation to internationalisation	Reviewing institutional goals in relation to inter/transdisciplinarity
	Reflecting on achievement and identifying opportunities for improvement	
Imagine	Discussing the cultural foundations of dominant paradigms in the disciplines and their relation to the curriculum	
	Identifying emergent paradigms and consider the possibilities they offer	
	Imagine the world of the future, including what will be needed to work effectively and ethically then	
	Imagine different ways of doing things	
	Brainstorm a range of possibilities to deepen and extend internationalisation and inter/trans disciplinary approaches in the curriculum	
Revise and Plan	Establish programme-specific goals for IoC	Establish STEAM goals to be included
	Detail intended learning outcomes and map the development and assessment in the programme	
	Identify blockers and enablers, experts, champions and resources	
	Set priorities and discuss how the changes will be evaluated	
Act	Implement new teaching arrangements and if necessary support services. Include workshops, and as required, new assessment, new units, courses, electives or rubrics	
	Collect evidence required for the evaluation of changes	

Evaluate	Analyse evidence, reflect on impact, consider gaps, summarise achievements.

The STEAM-IoC Synergies

Synergies between the two agendas are evident at various levels. First of all, working from the learning outcomes of an IoC, namely global perspectives: IoC demands competence in other languages. Disciplines have often been regarded as entailing specific 'languages', with attempts at cross-disciplinary collaboration often thwarted by colleagues 'not speaking the same language'. Indeed, the whole inter/transdisciplinary enterprise is sometimes conceptualized as a form of translation from one discipline into another. Having defined translation[3] as 'an act of invention that works by combining different elements into a congruent whole', Michel Serres has theorised that art can often be regarded a translation of science and vice-versa, if translation is regarded a process of communication that entails making connections and forging spaces between different domains. To Serres, these passages 'have the power to distort and transform' (Guldin 2016, 111). He further defined science as the sum of all messages optimally invariant with regard to any translation strategy, and persuasively argued Leibnitz has been translated into mathematics, Blaise Pascal into the paintings of Georges de la Tour and that William Turner translated thermodynamics physics into his painting *The Fighting Temeraire* (1838). For Serres, not only is the painting depicting the homonymous old sailing ship being towed by a combustion engine tugboat towards the place where it will be broken up for scrap a scale model of what is happening in society, with the engine replacing the sail, but also 'the canvas spit flames like steamboats. It stages Carnot's reflections on heat and temperature and their relation to energy and work [...] Turner anticipates the future theoretical developments of physics without having any direct knowledge of Carnot's thermodynamic circle' (quoted in Guldin p. 113.

In the same vein albeit from the perspective of physics, Michael Leyton has argued that inasmuch as shape is the result of force applied to physical objects, it can be regarded a means whereby the transformations that led to a given state of being are stored, or in his words, 'shape is equivalent to memory storage' (2006 1). Thus the shape of a bay for instance results from an inflow of water at the top part of a coastline that starts to dip inwards until a resistance against the water flowing is met. In this sense, the shape of the bay stores the memory of the process whereby it was formed. Building on this insight, Leyton has developed a theory on the appreciation of painting based mainly on mathematical and physical criteria—i.e. on mathematical language—, paying attention to shape, tension and balance, where 'geometry becomes equivalent to aesthetics' (p. 1).

[3] Indeed, in science, metaphors, whether exegetical/pedagogical or theory-constitutive, are essential. They generate insight and help perceiving connections 'that once perceived are truly present. They enable us to see aspects of reality that the metaphor helps to constitute. Metaphors show that conceptual boundaries are elastic and permeable and can be stretched and altered' (Guldin 2016 13-14), demonstrating the value of linguistic approaches to students of science.

From these perspectives, introducing students to other STEAM disciplines enables them to learn another language, and the work of artists and scientist teams such as that of Anna Dumitriu and her physician collaborators, featured here in **chapter X** as an example of art that is created by the means of bacteria, or of engineers and artists who design robots for the aesthetic beauty of their movements (Herath, Kroos and Stelarc 2016) are instances of languages in translation. The benefits of fluency in the 'languages' of both drawing and science can be expressed thus:

> The act of drawing is an act of recording. Science requires the recording of data to seek insights and patterns […] Long before the technologies of printing, photography, and digital imaging, drawing was the only way to create a representation of features, construction, orientation, or pattern [...] The alphabets and numerals that were developed later are drawn symbols for already standardized language. In mathematics, the symbols combine as visual shortcuts of communication to describe relationships and patterns. Drawing has been essential to our intellectual development. Where would science be without the drawings of Copernicus, Da Vinci, Audubon, Darwin, Bohr, Watson, Crick and Franklin, in depicting models, processes, and possibilities? (Katz 2016)

Equally, all arts and humanities programmes should include in their reading lists articles from scientific journals and vice-versa, to ensure that, as with internationalisation, 'other viewpoints are included and awarded due consideration'. The publication exchange project started at University College Cork in 2017 actively promotes the work of staff members among the university's international partners in close collaboration with Cork Open Research Archive CORA, the library's institutional repository, which serves as platform for their dissemination and archiving. Funded by the Irish Research Council, the project also receives publication contributions from the partner universities' staff that are interested in working through open access. A digital artist was enlisted to visualise the contents of the works exchanged as well as their spatial dissemination patterns as they are browsed or downloaded abroad, and some abstracts were translated into the participating languages (English, Spanish, Chinese and Portuguese). In this way, not only have the institution's international partnerships been strengthened through this academic collaboration, and its institutional repository has been enhanced, but the project has set the stage for STEAM exchanges when it is expanded beyond its initial scope in the arts, humanities and social sciences.

The second IoC learning outcome, namely intercultural competence, including sensitivity to the perspectives of others and a willingness to put oneself in their shoes, is currently focused on understanding the nature of racism. This sensitivity to the perspectives of others can be broadened by including gender and understanding of the nature of sexism that is at work in science and the arts as academic fields. Combining and juxtaposing the very different fields of electronics and sewing/embroidering, e-textiles bring together activities traditionally regarded as

feminine and masculine, and also hand and mind, formal and informal education, visible and invisible technology, physical and digital worlds, low and high tech, and the broader meanings of 'hard' and 'soft' (Buechley, et al. 2013). The embroidery has a crucial function conveying electricity, in such a way that ornamental design and functionality are not antagonists. They allow participants to express themselves creatively through the use of technology while developing important new skills, ideas and social connections. Providing digital textile courses and workshops promotes STEAM collaboration at its best while also increasing the number of female students in fields of engineering and electronics. From an IoC perspective, this would provide opportunities for the comparison of male/female roles in different cultures.

Moreover, the third learning outcome, ie responsible global citizenship, including understanding the necessity to engage with sustainability, can be addressed through university-wide modules such as the one implemented at University College Cork in 2015-16, which stands out as a model of good practice. Building on its green campus strategy, the module drew from the expertise of all colleges (Medicine and Health; Business and Law; Arts, Celtic Studies and Social Sciences; and Science, Engineering and Food Science) with volunteer lecturers from each teaching a highly participatory session each week to provide a truly relevant interdisciplinary—from the participants' perspective—learning experience, for all undergraduate and postgraduate students and staff, as this module was indeed also open to academic and non-academic staff, and eventually to the entire Cork community, including activists, employers and various stakeholders. In fact, following the success of this initiative, a second university-wide module on internationalisation is currently in preparation. In general, university-wide modules address the important issue of institutional blockers to STEAM.

In addition to working through the learning outcomes, a further instance of synergy between STEAM and internationalisation is the IoC process itself. The second step, 'reviewing and reflecting' as detailed above, requires identifying opportunities in both the formal and the informal curriculum to include internationalisation actions. Common ways to do this are inviting guest speakers and designing reading lists to ensure international viewpoints are represented and given due consideration: guest lectures by speakers from local cultural groups or international companies, international partner universities, or, increasingly, digital learning and online collaboration and comparative international literature are among the instruments to internationalise teaching and learning (Beelen and Jones 2015, 64). These guest lectures or even fellowships can also be recruited for the cultivation of STEAM. For example, the UCC Fulbright Fellowship usually ascribed to the College of Arts, Celtic Studies and Social Sciences is this time shared with the College of Medicine and Health for a range of activities across the formal and informal curriculum that will develop global medicine, and will be extended to include collaboration with the Environmental Research Institute. In this way, an international fellowship designed to promote scholarly exchange between Ireland and the US can at the same time promote STEAM.

Internationalisation at Home (IaH)

A subset from IoC, Internationalisation at home (IaH) is concerned with extending the benefits of internationalisation to students and staff that do not avail of study abroad or staff exchange programmes. One of the key contributions of IaH lies in framing a context for the development of employability skills (Beelen and Jones 2015, 68). Many studies have shown that international experiences are instrumental in developing the kind of transferable skills that employers value. Certainly, innovation, which employers highly value, is based in creativity, and this in turn is based in exposure to new people and new ideas, 'particularly through transdisciplinary social input' (Bridgstock 2017, 345). Exposure to new people and new ideas can be achieved by actively mobilising for this purpose an institution's network of international students and staff, who are bound to bring with them knowledge of different educational systems, and possibly of different paradigms of research and teaching (Altbach and Yudkevich 2017, 2). An employability and transferable skills training programme across disciplines can be matched to these efforts. Such a programme would focus on bringing skills traditionally associated with the arts and humanities—such as aesthetic appreciation, critical thinking or communication skills—to students of technology and science, while also bringing skills traditionally associated with science and technology—such as planning and problem solving, numeracy and the use of information technology—to students of arts and humanities, actively taking advantage of the innovative perspectives that international staff and students bring. Staff mobility is only effective when it is part of a deliberate process of staff development, as noted by Brewer and Leask (2012, p. 251). Likewise, the local community can become the focus of learning opportunities with intercultural and/or international dimensions, and expose students to STEAM frameworks.

Conclusions

At one extreme disciplines have been lauded as above 'the life and blood of higher education' while on the other they have been described as an abdication: 'by focusing on standards of excellence internal to a discipline academics have been able to avoid larger responsibilities of how knowledge contributes to the creation of a good and just society' (Frodeman, Thompson and Mitcham 2012, xxxii-xxxiii). Whichever view one subscribes, there is no doubt that disciplines were central to academic life of the twentieth century. But technology has changed society in a fundamental way. Fast data processing, artificial intelligence, robotics, networked communication and cloud computing are transforming production and consumption, not least of knowledge itself, as well as the labour market. It is estimated that in the next 10 to 15 years up to 50% of existing roles will be made redundant (Bridgstock 2017, 342). To take advantage of the new roles and opportunities that will be created the university must radically transform, embracing internationalisation and transdisciplinarity. As Gerry Stoker and Mark Evans argue, the issue is not how academia draws up its dividing lines, but rather which types of research can contribute to the problems we confront (2016 2). Internationalisation provides essential skills in cross-cultural communication and promotes global citizenship.

Transdisciplinary teaching offers a promising seed of knowledge-network activity. Teaching and learning methods that include student centred, problem-based, practice-oriented and community-based learning (Stütz, et al. 2014, 34), must become mainstream, while also including international partnerships and global outlooks and perspectives[4]. In this chapter I have discussed ways in which the internationalisation and the STEAM cultivation agendas overlap and how they can benefit from each other, suggesting practical ideas that can be implemented to this end. Internationalisation and Transcisiplinarity are important ways forward to make the university future-capable.

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[4] An example of curriculum developed for STEAM and internationalisation is the University of Northern Arizona's Global Science and Engineering Programme (GSEP), launched in 2011 to develop global capabilities. Students are required to complete a second major in an Asian or European language simultaneously and spend their fourth year abroad, half of it in a placement, and their fifth writing both capstone projects. Students indicated that their language major 'enabled them to use a different part of their brain' (Killick 2017, 200-201).

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