Full Steam Ahead! Guiding Principles for the design of Interdisciplinary Approaches to the Development of Communication Skills and Enquiry Based Collaborative Learning in STEM and Arts Subjects

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Our group project involves exploring interdisciplinary communication skills and collaborative learning across STEM disciplines. In order to examine the topic we completed a literature review and surveyed staff about their views on interdisciplinary communication and collaborative learning at undergraduate level. We will hold a focus group on the topic with staff in June 2014 and will pilot a 6 week programme based on our research in August/September 2014.

Though one of our intended project outcomes was a design model for interdisciplinary approaches to communication skills, as a result of the literature review we have redefined our purposes and we will instead, in the first instance, present guiding principles for the effective integration of interdisciplinary communication skills training into existing and future programmes. In this paper we outline the first draft of these principles which recognise interdisciplinary collaboration as a pedagogical 'trading zone' and see the development of communications between the disciplines as a necessary response to the realities of world complexity, the dissolving of boundaries between subjects, the need to combat excessive specialisation, the drive for rounded graduates who possess scientific literacy, critical and creative thinking, and expanded expertise, vocabulary and tool sets, in addition to the ability to communicate to wider audiences. It is with reference particularly to the latter that we report on how our principles have been impacted by the very recent moves to integrate arts-based subjects with STEM disciplines - moving from STEM to STEAM. We suggest that this is an important transition which we all need to be mindful of.

Our research is influenced by the following models and theoretical frameworks: the US Boyer Commission of 1998; Cousin's and Meyer and Land's work on threshold concepts; the Healey and Jenkins, and the Boyle and Bradley models of undergraduate research; the Aalborg model of project-oriented problem based learning; the work on transfer most recently by Moore in the States; by Wenger's work on communities of practice; and by pedagogical constructivist methods particularly the move from absolute to contextual knowing as based on the research of Marcia Baxter Magolda.

Learning across the disciplines has become increasingly more conspicuous and desirable in contemporary higher education. Where universities' pedagogical and

research approaches, and indeed structures, had evolved over time to be very clearly discipline driven, in the past 30-40 years, a shift has occurred which has resulted in a distinct move to also consider how the disciplines might (again) intersect and interact with each other.

As Weingart notes: 'Thus, disciplines … remain the primary organizational unit for the production and diffusion of knowledge. However, the process of differentiation … [has softened] the once rigid boundaries … to allow for the emergence of interdisciplinary fields…. traditional disciplines and inter-, multi-and transdisciplinary research fields will exist side by side' (Weingart 2010: 18). The necessity alone for language to describe this phenomenon suggests its prevalence. Klein's work is useful when examining this area as she attempts to evaluate this research field, noting the three phrases of multidisciplinary, interdisciplinary, and transdisciplinary in her work. With regards multidisciplinary exploration, Klein notes with particular reference to Stokols et al., that this involves 'juxtapositions of disciplinary approaches' but without modification of the disciplines (Klein 2008: 117). Interdisciplinary approaches are composed of stronger 'integrations and collaborations' involving the synthesis of two or more academic disciplines and their specific ways of thinking and methods, in pursuit of a common task.

Interdisciplinarity may feature when the subject is new, or neglected in traditional disciplines, such as, for example, global warming. Whereas transdisciplinarity, according to Klein referring to Rosenfield, occurs when 'different fields work together over extended periods to develop novel conceptual and methodological frameworks, with the potential to produce transcendent theoretical approaches' (Klein 2008: 117).

Our project involves exploring, what we are content to call, 'interdisciplinary' communication skills and collaborative learning across STEM disciplines. In order to examine this topic we completed a literature review and surveyed staff about their views on interdisciplinary communication and collaborative learning at undergraduate level. In addition, in late May 2014, we will hold a focus group on the topic with staff from our institutions and in Aug/Sept we will pilot a 6 week programme based on our research findings.

Though one of our intended project outcomes at the outset was to design a model for interdisciplinary approaches to communication skills, as a result of the literature review we have redefined our purposes and we instead, in the first instance, present guiding principles for the effective integration of interdisciplinary communication skills into existing and future programmes. In this paper we outline the first draft of these principles which recognise interdisciplinary collaboration as a pedagogical 'trading zone' and see the development of communications between the disciplines as a necessary response to the realities of world complexity, the dissolving of boundaries between subjects, the need to combat excessive specialisation, the drive for rounded graduates who possess scientific literacy, critical and creative thinking, and expanded expertise, vocabulary and tool sets, in addition to the ability to communicate with wider audiences. It is with reference particularly to the latter that we report on how our principles have been impacted by the very recent moves to integrate arts-based subjects with STEM disciplines -moving from STEM to STEAM. We suggest that this is an important transition of which we all need to be mindful.

Though a presentation of our comprehensive literature review is beyond the scope of this document, it is important to note that certain models and theoretical frameworks,

in particular, influenced our work. These included: the US Boyer Commission of 1998; the Healey and Jenkins, and the Boyle and Bradley models of undergraduate research; the Aalborg model of project-oriented problem based learning (POPBL); the work on transfer most recently by Moore in the States; Wenger's work on communities of practice; and pedagogical constructivist methods particularly the move from absolute to contextual knowing as based on the research of Marcia Baxter Magolda. Our thinking was also impacted by the case studies on multi-, inter-and transdisciplinary higher education projects that appear in the literature.

Our key contribution, at this point, is to suggest some guiding principles which we hope will continue to evolve throughout our own work. We do not suggest that these ideas are absolutes, but rather that they appear to be held out in the literature and that they resonate with our own thinking and that of our colleagues who contributed to the survey associated with this project.

Our principles, thus, in their current iteration are as follows:

1: Interdisciplinary communication requires at least two people from different disciplines who each know their respective disciplines. For experts in different disciplines to work together effectively, they need to be able to communicate with each other. Where they are not, first and foremost, experts in their chosen field/discipline then there is little point in them trying to communicate with experts in other fields/disciplines. Therefore, at undergraduate level, the priority is to become as expert as possible in one's chosen discipline in the first instance. This does not mean becoming an information-repository for that discipline. Rather, expertise at this level involves emergent knowing, acting and thinking in a way that is recognizable to those who are identifiably initiated in the field. This expertise is associated with a familiarity with the culture, and ease of use of the language and conventions of the discipline. It is demonstrated in, amongst other behaviour, speaking, writing, arguing/case-making, and thinking in the discipline.

2. Key to undergraduate students developing interdisciplinary communication skills, is a recognition by students of the need for these skills and their value and importance. At discipline-specific undergraduate level, therefore, the main objectives may be to ensure that students grasp the essential nature of both intra-and interdisciplinary communication skills. Facilitating interdisciplinary learning means creating awareness in undergraduate programmes of disciplinary identity, and the variety that exists between different cultures and discourse communities.

3. The prevalence of communication modules in STEM programmes is indicative of widespread acceptance among faculty of the importance of communication skills. However, the conventional 'bolt-on' module approach is not the most effective way to either engender an appreciation of such skills or to begin to develop them. Theconcept of an 'interdisciplinary communication curriculum' in isolation seems fundamentally flawed at undergraduate level. The communication skills components need to be contextualized through their integration into the programme. The Aalborg POPBL model is a good example of such an approach.

4. As a shared entry point, enquiry should be at the core of interdisciplinary learning for STEM undergraduates. We see research informed pedagogies as being especially useful in this regard e.g. Enquiry, Problem and Project Based Learning.

5. Interdisciplinary learning must involve collaboration and peer learning as essential elements of all interdisciplinary undergraduate STEM programmes.

6. The ability to communicate within and across the disciplines is a necessary higher education curricular goal in an age of 'supercomplexity' (Barnett, 2000) and in a world where 'wicked' multi-faceted problems will need to be solved.

7. This work is not only the domain of writing and rhetoric experts but rather that this work needs to be of concern to all teachers and learners. In this regard, discipline experts -academics -need to work collaboratively across the disciplines and with learning support staff to develop interdisciplinary approaches. This will certainly include working with librarians, teaching and learning staff, writing and oral communication experts, research experts, etc.

8. An emphasis on scholarship is useful when designing interdisciplinary programmes where scholarship means facilitating learning for the student, as emergent scholar (Baxter Magolda, Healy and Jenkins) and where the teacher is engaged in scholarship across Boyer's four areas (1998)

9. All programmes of this nature should reflect learner centred approaches and should include the capacity for some learner driven outcomes.

10. The move from STEM to an integration of the Arts and Art and Design as part of interdisciplinary learning, what is emerging in the literature as STEAM, should be welcomed. We note these guiding principles here as a work in progress and our contribution to the important conversation that is happening in this area at present.

References

Aalborg University, Denmark www.en.aau.dk/about+aalborg+university

Barnett, R. (2000) Realising the University in an Age of Super Complexity. Milton Keynes: OU Press.

Baxter Magolda, M. (1999) Creating Contexts for Learning and Self-Authorship: Constructive Developmental Pedagogy. Nashville: Vanderbilt University Press.

Baxter Magolda, M. and King, P. (eds.) (2004) Learning Partnerships: Theories and Models of Practice to Educate for Self-Authorship. Stylus Publ.

Baxter Magolda, M. (2008) Educating for self-authorship: learning partnerships to achieve complex outcomes in C. Kreber (ed.) The University and its Disciplines: Teaching and Learning Within and Beyond Disciplinary Boundaries. Oxford: Routledge 43-156.

Boyer Commission on Educating Undergraduates in the Research Universities (1998) Reinventing Undergraduate Education: a Blueprint for the American Research

Universities. Stoneybrook, NY. Carnegie Foundation for the Advancement of Teaching.

Boyle, Gerry and Bradley, Finbarr, 2005, The Undergraduate as an Engaged Explorer,

[online] NUI Maynooth ePrints. Available at eprints.nuim.ie/252/1/N160_09_05.pdf,

(accessed 2 May 2014).

Healey, M. and Jenkins, A. (2009) Developing Undergraduate Research and Inquiry. York: Higher Education Academy.

Klein, J.T. (2008) Evaluation of Interdisciplinary and Transdisciplinary Research: a Literature Review. American Journal of Preventative Medicine August 2008: S116-S12.

Moesby, E. (2002): From pupil to student – a challenge for universities: an example of a PBL study programme. Global J. of Engng. Educ., 6, 2, 145-152.

Moesby, E. (2004), Reflections on making a change towards Project Oriented and Problem-Based Learning (POPBL). World Transactions on Engineering and Technology Education, Vol.3, No.2, 2004.

Moore, Jessie, (2012). Mapping the Questions: The State of Writing-Related Transfer Research, Composition Forum: Composition Forum: Volume 26: Fall 2012

Rhode Island School of Design (RISD), What is STEAM? [online]. Available at http://stemtosteam.org/ (accessed 2 May 2014).

Rosenfield, PL The potential of transdiscipliary research for sustaining and extending

linkages between the health and social sciences. Soc Sci Med 1992; 35: 1343-57

Stokols D, Fuqua J, Gress J, et al. Evaluating transdisciplinary science. Nicotline Tob Res 2003; 5 (1S): S21-S39.

Wenger, E., R. McDermott and W. M. Snyder. 2002. Cultivating Communities of Practice: A Guide to Managing Knowledge. Harvard Business School Press.

Wenger, E. 1998. Communities of Practice: Learning, Meaning and Identity. Cambridge: Cambridge University Press.

Weingart, P., 2010. A Short History of Knowledge Formations. In R. Frodemann, J.

Thomson Klein, & C. Mitcham, eds. The Oxford Handbook of Interdisciplinarity. Oxford: Oxford University Press, pp. 3–14