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Gaining insight into interdisciplinary research and education programmes: A framework for evaluation

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ABSTRACT

Greater understanding of how interdisciplinary research and education evolves is critical for identifying and implementing appropriate programme management strategies. In this paper a programme evaluation framework is presented. It is based on social learning processes (individual learning, interdisciplinary research practices, and interaction between researchers with different backgrounds); social capital outcomes (ability to interact, interpersonal connectivity, and shared understanding); and knowledge and human capital outcomes (new knowledge that integrates multiple research fields). The framework is illustrated on an established case study doctoral programme. Data are collected via mixed qualitative/quantitative methods to reveal several interesting findings about how interdisciplinary research evolves and can be supported. Firstly, different aspects of individual learning seem to contribute to a researcher's ability to interact with researchers from other research fields and work collaboratively. These include learning new material from different research fields, learning how to learn new material and learning how to integrate different material. Secondly, shared interdisciplinary research practices can be identified that may be common to other programmes and support interaction and shared understanding between different researchers. They include clarification and questioning, harnessing differences and setting defensible research boundaries. Thirdly, intensive interaction between researchers from different backgrounds support connectivity between the researchers, further enabling collaborative work. The case study data suggest that social learning processes and social capital outcomes precede new interdisciplinary research findings and are therefore a critical aspect to consider in interdisciplinary programme management.

1. Introduction

Real world problems rarely regard disciplinary boundaries. Research that reflects the integrated nature of societal problems by joining together knowledge and understanding from different disciplines is essential to address the challenges facing society (Carayol and Nguyen Thi, 2005; Jeffrey, 2003; Klein, 1990; Repko, 2008). This is particularly apparent regarding water, essential for life and our economy and therefore an integral part of every aspect of our lives. A holistic approach to understanding water systems in their entirety is critical for sustainable management and requires research that takes place across multiple disciplines (Daily and Erhlich, 1999). Interdisciplinary research and education programmes aim to address this need by producing new knowledge through research collaborations across different research fields, while at the same time, developing interdisciplinary research skills in the future generation of researchers (Blöschl et al., 2012). Yet several authors have noted that greater efforts are needed in evaluating the effectiveness of such programmes in order to both demonstrate their value and understand how they can be improved (Boix-Mansilla and Dawes Duraising, 2007; Borrego and Cutler, 2010; Mitrany and Stokols, 2005; Saito et al., 2013).

Defining interdisciplinarity and determining its objectives is complex (Barry and Born, 2013; Klein, 2006; Siedlok and Hibbert, 2014). A broad and commonly used definition of interdisciplinary work is provided by the OECD, “interaction between two or more different disciplines. The interaction may range from simple communication of ideas to the mutual integration of organising concepts, methodology, procedures, epistemology, terminology, data and organisation of research and education in a fairly large field” (OECD, 1972 p. 25). This is somewhat different to the definitions of multi-disciplinary work, “the juxtaposition of various disciplines, sometimes with no apparent similarity between them," and transdisciplinary work, ‘establishing a common set of axioms for a set of disciplines’ (OECD, 1972 p. 25). Over the last few decades these definitions have been extensively revised and

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adapted (see Huutoniemi et al., 2010 for a comprehensive overview) and the range of conceptualisations are diverse. Some aim to capture the nature of the interactions (e.g. symmetrical or asymmetrical integration of two or more disciplines (Barry and Born, 2013)), others are concerned with the products that result (e.g. knowledge or methods (Schmid 2008, 2011)), and some include the participants involved and the expected beneficiaries of the resulting research (e.g. engagement beyond academics and academia (Pohl, 2011)). Two common themes tend to emerge. One is that the discipline is not the central construct for the research, rather the research question determines the disciplines that engage in the research, also known as mode-2 knowledge production (Gibbons et al., 1994; Nowotny et al., 2001) Another is that multi-, inter- and trans-disciplinary are often thought of as points on a continuum, rather than being mutually exclusive typologies (Golde and Gallagher, 1999; Huutoniemi et al., 2010). In this paper we have chosen to use the term cross-disciplinary to capture multi-, inter- and trans-disciplinary type research. We later differentiate between multi- and interdisciplinary work using the framework developed by Huutoniemi et al. (2010). We specifically explore research taking place between researchers from different research fields rather than also including cross-disciplinary work conducted solely by an individual or work that includes non-academic stakeholders (Pfirman and Martin, 2010).

Researchers have attempted to measure interdisciplinary outcomes in ways such as: i) the diversity of the journals in which a researcher has published (Carayol and Nguyen Thi, 2005); ii) the successful integration of knowledge and understanding through the forging of new fields or disciplines (Borrego and Newswander, 2008; Corley et al., 2006; Golde and Gallagher, 1999); or iii) the production of new knowledge, and the quality and quantity of that knowledge as measured by publications, grants, awards and citations (Carr et al., 2017; Porter et al., 2006; van Rijnsoever and Hessels, 2011; Wagner et al., 2011). Klein (2006, 2008) notes how objectives from interdisciplinary projects vary. New knowledge is one type of goal, but others may be the development of new approaches or products (e.g. medicines or measuring devices). The findings of these studies generally reveal that interdisciplinary programmes are leading to a variety of outcomes. However, we do not know enough about how these outcomes are emerging, what the factors are that support their development and ultimately, how we can increase the quality and quantity of interdisciplinary research. A framework is needed that can capture the outcomes, and couple them to the processes taking place within a programme that are leading to their achievement.

This paper aims to address this research need by proposing and illustrating the application of an interdisciplinary evaluation framework. We present a conceptualization of the interdisciplinary system for the interdisciplinary research community that captures processes and tangible and intangible research outcomes. Using the framework, we explore why and how interdisciplinary research is taking place in a case study doctoral programme. This leads to some observations about the linkages between processes and outcomes in interdisciplinary research programmes, and some general recommendations on how interdisciplinary research can be supported that may be of benefit to those engaged in such programmes. First a brief overview of the case study is given then the framework is explained. The indicators and data sets used to operationalize the case study evaluation are described and the results are presented. Some general recommendations for interdisciplinary programmes are drawn, and the framework is critically reviewed and the areas for further development are identified.

2. The case study: Vienna Doctoral Programme on Water Resource Systems

The Vienna Doctoral Programme on Water Resource Systems (www.waterresources.at) at Vienna University of Technology began in 2009 with funding from the Austrian Science Fund (FWF) and from the university. It is currently in its eighth year and is designed to run over a period of 12 years. An anticipated 70 students will have graduated by 2021. The goal of the programme is to achieve interdisciplinary cutting edge research at the international level and turn out graduates who go on to work in leading organisations from the public, private and academic sectors. To this aim, students complete their PhD through publications in international peer reviewed journals (a minimum of three papers where the student is first author are required). Researchers are encouraged to submit their work to one of the leading journals in their field (based on journal impact factor).

Ten research fields are included in the programme reflecting the university departments and research focus of each of the ten faculty members – aquatic microbiology, hydrology, hydro-climatology, hydro-geology, mathematical economics, photogrammetry, remote sensing, resource management, structural mechanics, and water quality. These are described as *research fields*, as they represent groups of researchers addressing knowledge domains, rather than traditional academic disciplines (Huutoniemi et al., 2010). Since the start of the programme, 50 international doctoral students with diverse academic backgrounds have been enrolled and to date, 24 have graduated. Seven programme graduates continue to be involved as associate post-docs, along with three other associate post-docs (one of whom is the programme coordinator). Efforts have been made from the onset of the programme to create a physical and intellectual environment conducive for interaction among the researchers through implementing a number of approaches, described in Table 1.

Table 1
Approaches to promote cross-disciplinary interaction in the programme.

Approach	Details
Shared offices	One open plan office hosting 7 students and programme coordinator. Other students hosted in their supervisors' departments, 8 of which plus programme office are located in the same building, Two are located in different buildings.
Study programme	Each faculty member teaches a compulsory basic course on their research field which each student must take, and students can chose from a variety of elective courses for more advanced study on topics that interest them.
Seminar series	A monthly seminar series given by leading researchers from around the world on topics of interest to programme researchers.
Research cluster meetings	Each programme participant is a member of at least one research cluster group (water resource management, land-surface processes, Hydrological Open Air Laboratory, water and health, modelling and risk). The regularity of their meetings (monthly to six-monthly) and content (presentations by members of the group, review of manuscripts, or research planning such as fieldwork and experiments) varies considerably between the clusters.
Joint supervision	Each student has a primary supervisor and a supporting supervisor from different research fields.
Annual and six-monthly symposia	Symposia bring all members of the programme together for one day (six-month symposium) or two days (including an overnight stay away from the university) (annual symposium). They typically involve short presentations and posters from research students on their research progress, extended questioning time to stimulate discussion, workshops and small group meetings for brainstorming, and evening group games to promote informal interaction between all programme researchers.
Shared study sites	In the shared field study sites students with different specialisations work directly together to address their research questions. For example, in the Hydrological Open Air Laboratory (HOAL) and the Danube Porous Aquifer (both located close to Vienna) students support each other in data collection and designing and conducting experiments (see Blöschl et al., 2015 for details of the HOAL).