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Reflections on Practice

Cultivating 21st Century Skills in PhD Students

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ABSTRACT

The complex nature of 21st-century challenges requires PhD holders to not only be specialised and independent, but also open-minded and critically reflective. Doctoral training needs to be updated in order to place greater emphasis on key skills such as interdisciplinarity, critical thinking, and collaboration. In this Reflection on Practice (henceforth referred to as 'Reflection'), I propose three interventions that I believe would help put the "Philosophy" back into "Doctor of Philosophy". Firstly, a pedagogical model that makes the interdisciplinary research process explicit for students so as to promote effective collaboration and communication, and to facilitate the integration of disciplinary insights. Secondly, a "toolbox" for philosophical dialogue, consisting of questions that would motivate students to articulate philosophical similarities and differences between their respective disciplines, and enable them to implement the above model effectively. Thirdly, applying blended learning as the overall instructional mode to facilitate interdisciplinary critical thinking, collaboration, and communication. My hope is that this approach, which combines the three interventions, will develop individuals who are more creative, critically reflective, and well-prepared for a multitude of careers. I also believe that the interventions proposed herein would fulfill the objectives of lifelong learning by nurturing a labour force that is competent and bold enough to face a volatile, uncertain, complex, and ambiguous (VUCA) world.

INTRODUCTION

The term "Doctor of Philosophy" or "PhD" typically refers to an expert who is highly specialised and capable of conducting independent research in a particular field or discipline. However, the multifaceted challenges of the 21st-century require that PhD holders not only be specialised and independent, but also open-minded and critically reflective. It is thus important that PhD students be able to look beyond the confines of their disciplines and situate their research in a wider context. The complexity of the challenges that we educators face means that in order to formulate solutions to real-world problems, we need to adopt an interdisciplinary and critically rationalist approach that emphasises philosophical elements that train students to critically think and do interdisciplinary research (Bosch & Casadevall, 2017).

At the Graduate School for Integrative Sciences and Engineering (NGS) at the National University of Singapore (NUS), our core courses have traditionally relied upon modes of instruction and assessment that primarily test a student's content knowledge, with less emphasis placed on developing critical thinking and collaborative skills. Thus, based on experience, we know that students are less likely to critically discuss their assigned interdisciplinary tasks in a collaborative manner. Moreover, our students tend to be reserved during face-to-face sessions (which seems to be a general observation in the Singapore context), thus further inhibiting collaborative discussions.

In this Reflection, I discuss why critical thinking and interdisciplinarity are important, and how these two elements can be integrated into the core curriculum of NGS, which mandates three postgraduate modules: "Academic Professional Skills and Techniques", "Research Ethics and Scientific Integrity", and "Interface Sciences and Engineering".

PROMOTING CRITICAL THINKING & INTERDISCIPLINARITY

In a world where problems are becoming increasingly complex, we need PhD students who are able to situate their work in ever wider contexts. Recognising this need, some have called for doctoral programmes to be reformed such that students are trained to become critical thinkers and not just specialists. To promote both interdisciplinarity and philosophical reasoning, PhD students should be given opportunities to exercise their critical thinking skills by challenging assumptions, engaging in creative problem-solving, and meaning-making within active learning contexts (Bosch, 2018). Simply put, the "Philosophy" needs to be put back into "Doctor of Philosophy".

As cited by Mayer and Alexander (2016), a framework based on the Partnership for 21st Century Skills states that critical thinking is a learning and innovation skill essential for success in the 21st century. The Association of American Colleges and Universities describes critical thinking as a mental habit whereby ideas and events are comprehensively explored before a conclusion is reached (Association of American Colleges & Universities, 2009). Singapore, too, has emphasised the development of 21st-century competencies through its educational policies and curriculum frameworks (Tan, Choo, Kang, & Liem, 2017). As a metacognitive process involving analysis, evaluation, and inference, critical thinking helps to generate a logical conclusion to an argument or a solution to a problem (Dwyer, Hogan, & Stewart, 2014, p. 42), thereby strengthening students' reasoning abilities and nurturing reflective practitioners who would be better prepared for global challenges and diverse careers (Bosch & Casadevall, 2017).

Alongside critical thinking, another 21st-century competency that we want to cultivate in our students is interdisciplinarity. By exposing students to multiple points of view, we hope that they will become more creative, reflective, productive, and thus better problem solvers. This is important because "research problems in the real world seldom arise within discrete disciplines and neither do their solutions" (Palmer, 2001, p. vii). Such a curriculum will, however, need to move beyond mere exposure to multiple disciplines and facilitate the integration of disciplinary insights. To that end, we would adopt a practical definition of interdisciplinarity, namely, as a "process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline, and draws on the disciplines with the goal of integrating their insights to construct a more comprehensive understanding" (Repko & Szostak, 2017, p. 8). Interdisciplinarity would empower an individual to deal with complex problems by effectively translating his⁄her education to new contexts, without getting intimidated by disciplinary experts or feeling pressured to adhere to his⁄her own disciplinary standpoints (Repko, Szostak, & Buchberger, 2017).

As PhD students, the process of honing our critical thinking skills tends to be shaped by our discipline, including its unique characteristics and context. As a result, that particular way of thinking becomes deeply rooted and we may end up believing that it is the only right way of thinking (Holley, 2009, p. 47). As explained by Repko, Szostak, and Buchberger (2017), critical thinking varies from discipline to discipline because the academic context is usually disciplinary in origin and the mental processes involved in problem

solving are situated in a specific field. They argue that an interdisciplinary approach would confer unique benefits because it would contribute to the development of critical thinking in the following three ways (Repko, Szostak, & Buchberger, 2017). Firstly, interdisciplinary students would experience the methodologies, processes, and products of relevant disciplines from an unbiased and comparative perspective (Toynton, 2005, p. 10). Secondly, interdisciplinarity fosters "intellectual dexterity", defined as the ability to speak from a wide range of experiences and knowledge (Huber, Hutchings, Gale, Miller, & Breen, 2007). Thirdly, interdisciplinarity shifts the focus from a narrow disciplinary context to a broader interdisciplinary one, i.e. students will master critical thinking strategies with general applicability rather than those designed for a particular disciplinary context.

Because critical thinking essentially depends on metacognitive skills and strategies to promote reasoned and purposeful thinking (Halpern, 2007; Mayer & Alexander, 2016), I believe that the most appropriate theoretical framework for designing learning interventions that promote higher-order critical thinking is Anderson and Krathwohl's (2001) updated Bloom's Taxonomy. This same taxonomy is the basis for an interdisciplinary research (and learning) model conceived by Repko and Szostak (2017). Dubbed the Integrated Model of the Interdisciplinary Research Process (IRP), the model is broadly divided into two parts: (1) drawing on disciplinary insights, and (2) integrating disciplinary insights. Integration is the hallmark of interdisciplinarity, and the IRP model is designed for both the individual researcher and groups of researchers. In making the interdisciplinary process explicit, the IRP would help facilitate communication between collaborating researchers, both in class and the workplace.

The students of NGS' core interdisciplinary module represent diverse disciplines. For group presentations on different interdisciplinary topics, I divide the class into groups of individuals from the various disciplines. An important question is: What are the challenges associated with attempting to promote collaboration between students from diverse disciplines so that they can address an interdisciplinary question or problem? Communication challenges may arise because different members understand the same word differently, or because different disciplinary backgrounds mean students hold different perspectives, which may lead to disparate assumptions being made (Repko & Szostak, 2017). Also, despite the fact that they are graduate students approaching the halfway mark of their PhD candidature, our students tend to be reserved in class.

REDESIGNING THE PhD CURRICULUM

In response to the need to reform PhD programmes, we wish to redesign our core curriculum to better promote interdisciplinarity and critical thinking. To achieve this objective, we propose a new design that rests on three pillars: (1) the IRP model, which provides students with a roadmap of the interdisciplinary process (see Table 1, in Appendix 1); (2) a "toolbox" for philosophical dialogue (the "Toolbox Project"), which consists of a set of questions that will help interdisciplinary collaborators articulate philosophical similarities and differences between their respective disciplines; and (3) blended learning as an instructional mode to facilitate interdisciplinary critical thinking, collaboration, and communication.

The "Toolbox Project" is a set of questions (see Table 2, in Appendix 2), originally developed at the University of Idaho (Eigenbrode *et al.*, 2007), designed to elicit the views of collaborating scientists on the philosophical aspects of research. These questions deal with both epistemological (motivation, methodology, confirmation) and metaphysical (objectivity, values, reductionism and emergence) issues, thus providing the structure to group discussions, and encouraging collaborative teams to take a philosophical approach towards evaluating key aspects of their projects (O'Rourke & Crowley, 2013). These questions will enable participants to appreciate the perspectives of other disciplines, and thus help reveal assumptions that might complicate interdisciplinary research. By improving interdisciplinary communication and being explicit about disciplinary perspectives, students will be able to critically discuss their assigned interdisciplinary tasks more effectively and thereby achieve the learning objectives of the curriculum.

To help students benefit fully from the IRP model and the Toolbox Project, I suggest using blended learning as an instructional mode to create opportunities for group discussions in a "safe" environment outside the classroom, thus promoting interdisciplinary collaboration, communication, and critical thinking. Blended learning, defined as "the organic integration of thoughtfully selected and complementary face-to-face and online approaches and technologies", facilitates the formulation of evidence-based arguments by rendering the thinking processes visible, which ultimately helps students to become independent thinkers (Burgess, 2009; Garrison & Vaughan, 2008; Huang, Hung, & Cheng, 2012). Online learning activities such as micro-lectures and discussion forums would give students time to review interdisciplinary material before they attend face-to-face sessions. The Toolbox Project questions described above could be deployed online, for example,

in the discussion forums, which, to my knowledge, has not been attempted yet. Scaffolding in the form of instructor and peer feedback would stimulate interdisciplinary reflection. In addition, we hope that blended learning will also help students build up their confidence for subsequent face-to-face discussions with their peers and instructors. Newer approaches involving technology-enhanced learning have proven effective at developing critical thinking skills by improving student motivation, guidance, scaffolding, and feedback (Giraldo-Garcia, Roy, & Alotebi, 2015).

CONCLUSIONS

With the help of the IRP model, the Toolbox Project, and blended learning, we hope that our PhD students will be better prepared for teamwork in academia and beyond, and that they will also become more reflective and critical as practitioners. In developing 21st-century competencies in critical thinking and interdisciplinarity, these interventions could help fulfill the objectives of lifelong learning by nurturing a competent labour force bold enough to face a volatile, uncertain, complex, and ambiguous (VUCA) world. Changes in technology have made the capacity to think critically and across disciplinary boundaries especially important for the workforce of the 21st century.

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APPENDIX 1. INTEGRATED MODEL OF THE INTERDISCIPLINARY RESEARCH PROCESS (IRP): INDIVIDUAL STEPS

Table 1

Individual steps of the IRP (Source: Repko & Szostak, 2017)

A.	Drawing on disciplinary insights
1.	Define the problem or state the research question
2.	Justify using an interdisciplinary approach
3.	Identify relevant disciplines
4.	Conduct the literature search
5.	Develop adequacy in each relevant discipline
6.	Analyse the problem and evaluate each insight or theory
B.	Integrating disciplinary insights
7.	Identify conflicts between insights and their sources
8.	Create common ground between insights
9.	Create a more comprehensive understanding
10.	Reflect on, test, and communicate the understanding

APPENDIX 2. TOOLBOX PROJECT: TYPES OF QUESTIONS

Table 2

Types of questions listed in the Toolbox Project (Source: Eigenbrode, O'Rourke et al., 2007)

Principal Philosophical Domain	Core Questions	Probing Questions
Epistemology		
Motivation	Is applied research or basic research more important to you as a researcher?	Is basic research inherently disciplinary research or can cross-disciplinary research address basic research questions? How do basic and applied research relate to each other in the traditions of your discipline and in the current team project?
Methodology	In your typical disciplinary research, what methods do you use, and which are most appropriate for your collaborative study (e.g. quantitative, qualitative, experimental, case study, observational, modeling)?	How are your methods related to those used by other members of your team? How does the spatial or temporal scale of your research approach compare and interact with the scales of your team's research approaches?
Confirmation	What type and amount of evidence are required for knowledge in your work?	What is required to ensure measurements are valid? In what way do your research conclusions address or incorporate uncertainty?
Metaphysics		
Objectivity	Must scientific research be objective to be legitimate?	Can one integrate values into research and still remain objective? Do you think it is valid to use one's personal perspective to frame a research question or hypothesis?
Values	Is value-neutral scientific research possible?	Do you consider questions about when hypotheses count as knowledge to be value questions? If you regard values as an ineliminable part of scientific research, how can they be managed to avoid biasing research results and interpretation?
Reductionism & emergence	Can the world under investigation be fully reduced to individual, independent elements for study?	Are there emergent properties of the system or subject of study, or is it reducible? Are multiple-scale (spatial, temporal) interactions important? To what degree can and should these be addressed?