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A Difficult Journey: Transitioning from STEM to SoTL

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This essay unearths difficulties experienced by scholars trained in the STEM disciplines when transitioning into the research context that is SoTL. We, a scientist and an engineer, engaged in a series of audiotaped reflective discussions (facilitated by a social science researcher) designed to tease out the difficulties associated with this contextual shift. Our discussions pointed to issues that go beyond the oft-quoted methodological differences of a quantitative versus qualitative approach, speaking instead to barriers associated with: time, emotions, intellectual training and world-views. Embracing a complexity approach to the generation of knowledge and understanding led us to an appreciation of the role of narrative and allowed us to dissolve dualisms that we had associated with STEM and SoTL. Our next step is to extend the conversation to include other 'scholar-travelers' in a series of workshops aimed at addressing the barriers and bridges associated with journeying from STEM to SoTL.

Keywords
STEM to SoTL, Disciplinary perspectives, Complexity, Scholar-travelers

A Difficult Journey: Transitioning from STEM (Science, Technology, Engineering and Mathematics) to SoTL

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Abstract

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Introduction

The Eminence of Research over Teaching within STEM

When the first Universities were established in North America in the 1600s the primary role of faculty was to teach and mentor students. The universities were established by English settlers who brought with them the traditions of the English collegiate system in which students studied with faculty 'mentors' who were responsible for furthering both their academic and moral development. The role of the University as a center for *teaching and learning* is captured in Harvard's founding mission "to advance learning and perpetuate it to Posterity" (Tyack, 1967, p.2). This was echoed two centuries later by Harvard's then president, Charles W. Elliot, who stated that "the prime business of American professors….must be regular and assiduous class teaching" (Metzger, 1987, p.135). By the late 19th century, however, the role of the University, and of the scientists therein, had radically changed.

The German model of the Research University entered America in the 19th century with the first Doctor of Philosophy being conferred at Yale in 1861 (Furniss, 1965, pp.24-45). The notion that it was research and not teaching that was central to the mission of a University gradually took hold. This resulted in the founding of new institutions like the Massachusetts

Institute of Technology (MIT, in 1861) and Johns Hopkins University (in 1876), which were dedicated principally to this goal. When, in 1802, Benjamin Silliman joined the 20 other science faculty in North America as the first chemistry professor at Yale (Wolfle, 1972, P.5), he was hired to teach what was known about science to undergraduates. However, by the close of the century, the University of Chicago stated that new academics needed to "sign an agreement that …promotions in rank and salary would depend upon research productivity" (Cowley, 1981, p.160). This shift in emphasis, from teaching to research, prompted the emergence of a two-tier system in American universities. Faculty hired to bigger, and oftentimes private, universities were expected to advance their, and the university's, stature by making public the results of their original research. Meanwhile the task of educating the next generation of citizens was delegated to post-secondary colleges and state Universities.

The second world war, and America's involvement in it, gave rise to the next change in the role of STEM scholarship at the University. The most prestigious Universities offered the services of their top science faculty to the war effort through the Manhattan (Engineering District) project that created the atomic bomb. In addition to the nation's top scientists, the Manhattan Project employed more than 12,000 college graduates (Fromm, 1997). Also, as part of the war effort, MIT's Vannevar Bush established the National Defense Research Committee. This subsequently became the Office of Scientific Research and Development, through which Government money flowed to science research (Bush, 1945). The tradition of using one's faculty position at the University to garner money to conduct STEM research was born.

STEM academics began building large research teams and employing prospective Ph.D. students, in order to advance their name through increasing numbers of specialized publications. This led to the current quantitative measures of a faculty members' contribution to the University based on the number of dollars attracted, number of Ph.D. students trained and number of papers published. These measures ignore the teaching, learning, and advancement of undergraduate students.

The Emergence of SoTL

It was against this background of the eminence of the research mission over the teaching mission, that the Carnegie Foundation for the Advancement of Teaching through its Presidents Boyer (1979-1995) and Schulman (1997-2008) began to question and report on the nature of scholarship and the priorities of the Academy in post secondary education. The Boyer report (1990) argued for a scholarship that included, alongside original research, building interdisciplinary connections, applying knowledge, and, disseminating knowledge. He named these four areas of scholarship as the scholarship of: *discovery*, *integration*, *application* and *teaching*. His report, and in particular his inclusion of teaching as a form of scholarship, laid the groundwork for a new field of scholarship within the academy that has emerged over the last two decades referred to as the Scholarship of Teaching and Learning (SoTL).

Boyer's report brought to critical attention the conversations that were happening at some of America's research-intensive Universities about a new approach to teaching and learning. For instance, Stanford University's president of that time, Donald Kennedy, in an address entitled "Stanford in its Second Century" called for more contact between faculty and students and stated that "It is time for us to reaffirm that education--that is, teaching in all its forms--is the primary task" of higher education (Gordon and Roark, 1990). Establishing the boundaries of this new academic field was not easy, demanding answers to questions relating to **what** this new field was about and **who** was qualified to engage in it

(Hutchings, 2010). Schulman attempted to address these questions by looking at SoTL across different academic disciplines. In quoting the mathematician turned philosopher Alfred North Whitehead (1861-1947) who entreated one to "seek particularizations...and distrust them" and, at the same time, to "seek generalizations...and distrust them", Schulman urged SoTL scholars to engage in both conversations, that is, to be effective, hey need to use discipline specific particularizations and inter-disciplinary generalizations (Schulman, 2002, pp. 7-11). In "Disciplinary Styles in the Scholarship of Teaching and Learning", Huber and Morreale (2002, p. 15) agree that SoTL scholars must speak in discipline specific 'language' to be heard and read within their discipline. But, in order to establish a true cross-disciplinary scholarship associated with teaching and learning they must share their insights, ideas and findings in an inter-disciplinary "trading zone", (so named by Peter Gallison, 1997).

But, what if the scholarly language, and culture, native to this 'trading zone' is foreign to discipline-specific scholars wishing to enter?

Foreigners in the Trading Zone

We, a scientist (Niamh Kelly) and an engineer (Susan Nesbit), set out to explore this question together. Over the course of six months we discussed our experiences transitioning from STEM practitioners to SoTL scholars in four facilitated reflective sessions and a blog. The sessions were facilitated by a social science researcher (Carolyn Oliver), who started with a semi-structured interview approach, asking us to reflect on our reasons for engaging with SoTL and on the challenges it posed. We quickly transitioned to unstructured discussions in which the facilitator's role became to observe our engagement in the process of reflection and to point out differences in individual perspectives in ways that allowed them to be explored and clarified.

Reflective interviews were chosen as the primary means of data collection because they required us to enact a key SoTL technique, namely, active reflection (Gelter, 2003). This offered us two levels of data. We discussed our challenges with SoTL processes like reflection and storytelling and these discussions were transcribed and analysed. We also demonstrated, and sometimes surmounted, these challenges through our active engagement in the study sessions. Our thoughts as to the strategies we were using to engage in the reflective sessions of the study, and the facilitator's written observations of those strategies, became a second level of data for analysis.

Joint interviews have been described as an effective means to uncover the different kinds of knowledge held by each participant and to produce a more comprehensive picture as interviewees prompt each other to go deeper and to explain themselves more fully (Seymour et al., 1995). Our experience was that the joint process shared the advantage of focus groups which "excel at uncovering *why* participants think as they do" (Morgan, 1998, p. 25). As we pushed each other to describe and explain our experiences we came to new realizations about those experiences and moved forward in our engagement with SoTL. We could track changes over time in the way we talked and felt about SoTL. We could not have written this paper at the study's outset as we had either not yet experienced or not yet recognised the conclusions contained herein. We have illustrated our conclusions with quotes from our original sessions to give the reader a clearer picture of our process and to acknowledge that this, like the journey from STEM to SoTL, is one that takes place in irreversible time.

The sessions were audio-recorded and transcribed. A qualitative description approach (Sandelowski, 2000) was used to analyse the data from the reflective sessions. Carolyn Oliver organized the data into broad groupings and examined the relationships between, and within, groupings to identify themes. We reflected together on the initial thematic analysis and these reflections were incorporated into the final analysis. This produced conclusions that we agreed had descriptive validity, in that they were an accurate accounting of our discussions, and interpretive validity, in that they constituted an accurate reflection of the meanings given by each of us to these discussions (Maxwell, 1992). Niamh Kelly and Susan Nesbit then identified the most resonant themes for discussion in this paper.

It takes Time….

While wanting to conceptualise the intellectual shift from STEM to SoTL as something minor and manageable, we acknowledged during our discussions that it was far greater than we had envisaged. This intellectual shift has previously been represented in the literature as a matter of learning a new set of skills, with the support of SoTL mentors (Hubball et al., 2010), devoting time and resources to faculty development (Donnelli et al., 2010), and/or establishing SoTL-appropriate merit systems and tenure procedures (Walker et al., 2008). Yet, we, who are well-situated in advantaged positions supported by the interventions described in the literature, experienced noticeable difficulties. It became apparent that the shift demands an immersion in a different intellectual language and culture, experiential learning, personal reflection and an iterative process of moving backwards and forwards between the familiar STEM approach and a different way of thinking. Above all, it demands time:

> Think about the time it takes you to learn a language, even if someone gives you the grammar, the words, the sentence construction...its enculturation, it takes time and that's the bit that to me has been missed in the literature. It's sort of like 'Oh yes we understand there's problems, here they are, we list the problems now just go along and tick off your problems'. Well enculturation isn't something you can do, it's a process that takes time... it's a process of internal dialogue, struggle and it's an iterative process.

The research culture associated with STEM that has emerged over the last century has spawned generations of scholars trained in specific ways of thinking within and about their discipline. Changing these thought processes, changing epistemological beliefs and attitudes, takes time, at both the community and individual level. Acknowledging the extent of the distance between STEM and SoTL seemed to be an important first step in clarifying why the journey seemed so hard.

…..and an Emotional Toll

We spoke about the new intellectual culture of SoTL as something far removed from our usual discourse. We prefaced many of our comments about qualitative methodologies, the humanities, constructivism and what we perceived as a SoTL approach by expressing uncertainty and a feeling of ignorance because "all of a sudden you're not an expert". We tended to "other" and stereotype the SoTL culture, implying its strangeness and the magnitude of the transition we felt we needed to make. We wondered whether "in a humanities environment there …[would be comfort]… in not being able to articulate what you're trying to say...or would there just be some sort of trained experience enabling you to do that quickly?" Non-STEM academics were stereotyped as inductive thinkers, comfortable with uncertainty and eschewing prediction. They had different physiology: "the physical fact of constructivism, the dendritic structures that grow in your brain as you think". In a recent essay, Tremonte (2011) talked about the fear associated with 'novice-stry', how in a career

path that holds 'credentials of knowledge expertise as it's prerequisite', the challenges when thinking about engaging in this new SoTL field can be daunting.

We discussed the fact that the shift demanded by engagement with SoTL impacted our personal as well as our professional lives. We had begun with the belief that it was simply our professional and academic training as a scientist and an engineer that made our engagement with SoTL more challenging. We began to realize, however, that:

> it's not that we are travelling from a position of academic learning or academic culture into another, but it's more that we may have gravitated to a natural academic culture because of who we are and now, for whatever reasons, we're travelling to another one and what does that mean for who we are, not just for how we were trained?

We had both starting reading novels, hand-in-hand with an appreciation of the value of narrative, and we talked about looking anew at parenting. "This is offering me a way to not only embrace something new within my job but my job's offering me … a new way of looking at the world."

Beyond Quantitative and Qualitative

Although we came to realize that what we were engaged in was a significant transition, a journey, from our normal way of thinking and working within STEM to a different way of thinking and working as reflective practitioners, and SoTL researchers, we had started our conversations by defining the journey as moving "from a quantitative to a qualitative perspective". (This was the title of a blog that we had established to continue our conversations beyond the facilitated reflective sessions and our first post was dedicated to defining the differences between quantitative and qualitative methodologies.) We later identified that in doing this we had taken:

> a typical science approach, this two hours has been about 'what is the journey, what is the journey?' And it's almost like that's the quantitative, the scientist, who says we'll name it and what are we doing about it?

The challenges in engaging with SoTL arose from the fact that it involved far more than the simple matter of learning new skills and becoming versed in new qualitative methodologies; the process could not be so neatly defined. The journey was not a matter of simply adopting a new methodological stance, it was more about moving from the culture of one intellectual discipline to another:

> I see this as a … more social sciences way of approaching something...it's a more humanities way of approaching thinking as opposed to a scientific way of thinking. So quantitative and qualitative are just two terms and there's also humanities and science.

Yet even these disciplinary distinctions were unclear as "medicine and the history of medicine...came from the humanities way back ...same with arts, same with engineering". We came to realise that dichotomised definitions such as: quantitative and qualitative, humanities and science, inadequately capture the journey to a different way of reasoning, working, and being in the world that is SoTL.

> We talked about how qualitative and quantitative research methods can overlap and augment and complement one another ... does that mean we're

> talking about epistemological beliefs, how … people construct those beliefs – it's not that we're either one or the other, that they're mutually exclusive beliefs, it's that we're on a continuum, or maybe that's also not the right way to describe it?

Changing one's World View and Embracing Complexity

A key finding was the emergence from our conversations of the notion that engaging with SoTL necessitated embracing a new worldview - "a worldview that has a deep understanding of complexity and messiness versus a worldview that really doesn't acknowledge complexity". For one of us, this intellectual shift was familiar: Sustainability is a core concept in 21st century engineering practice. Whereas the post-war era of engineering science arose from modeling the biophysical world with the natural laws of normal science, the theoretical basis of sustainability engineering, including industrial ecology, life-cycle assessments, and systems-thinking, is founded in complexity science. The late James Kay, physicist and theoretician of thermodynamics and complexity science, a professor of environmental and resource studies with cross-appointments in systems design engineering and urban planning at the University of Waterloo, explained that in "…viewing the biophysical world through the lenses of complexity … our understanding … changes. Where once we saw clockwork mechanisms, we now see self-organization and nested hierarchies characterized by evolution and emergence, attractors, rapid changes, and flips. … A complicated system can still, in principle, be predictable; a complex one is irreducibly uncertain" (Kay, 2008, p. 78).

Like understanding the foundations and applications of sustainability, we both agreed that the intellectual journey toward SoTL involved moving away from a traditional deterministic science perspective that emphasised cause and effect thinking, deduction and the quest for proof and certainty. "One of the reasons that [traditional scientists] don't acknowledge complexity is that as soon as they see it they deduce and ...they bring it to the simple, to the formula, to the measurable, to the hypothesis." On the other hand "now I've moved into another language that embraces different ways of thinking, like it embraces the thing of uncertainty, it doesn't look for proof and so it's allowing me to reason about knowledge in different ways". We came to the realisation that success in SoTL demanded embracing complexity.

Regehr, in writing about medical education research, spoke about the necessity for a similar shift, from the scientist's 'imperative of proof' towards the 'imperative of understanding' implicit in a complexity approach (Regehr, 2010). A defining characteristic of a complexity perspective is the belief that activities in the social world are nonreplicable and idiosyncratic. A complexity perspective values description and contextualised understanding as much as explanation and generalization; it implies an inductive and abductive approach to inquiry rather than deduction. It also demands a shift from the competitive approach of the sciences to a more collaborative approach because:

> There … are … other equally valid areas of expertise that you're compelled to acknowledge when you start thinking about complexity...so people around the table, all coming from a vast array of backgrounds, are trying to put words to the same ideas. As a colleague describes it, it's like you're in a forest at night, it's dark and you come with your one flashlight and you look at the forest. But the more people with the more flashlights, the more of the forest you're going to see. And that makes … sense when you're in this complexity realm.

The role of Narrative

When we thought about presenting our scholarly work in a field that honoured complexity, that accepted contextualised and non-replicable observations, we began to understand the relevance of narrative as a methodology. "Stories are a way of capturing complexity that you cannot capture in argument, in adversarial argument, or in a measure". Traditional science training allowed little room for stories and the scientists' response was often "it's nice [that you have a] … story. But you know really, I don't want to hear it. I just want to get to the bullet points". Having come from this view of stories, we have come to appreciate narrative as an effective tool for conveying intuitive knowledge, teaching complex ideas and engaging learners' emotions:

> let's say I come in and I tell you a story about something that happened . . and I leave it there, you don't say anything. You don't say anything, and as you drive away you begin to think about it, and you think about it for your case and a little gem of something that was in my story speaks to something in yours, and as you think more about it you change something in, or it influences, your situation; no argument.

The power of narrative, of storytelling, as a means of processing and conveying one's understanding is recognized in the social sciences and in such humanities fields as historiography (Stone 1979). It is acknowledged in the field of medicine, with the use of illness narratives and narrative therapy (Sulik, 2010; Gold 2007) and in education, with the rise of narrative research, case based learning and storytelling (Casey, 1995-1996; Flyvbjerg, 2011; Collins 1999). One of the few fields of endeavor which it has not penetrated is that of STEM, which tends more towards a presentation of objective evidence as a means of conveying emerging knowledge and understanding rather than contextualized, descriptive storytelling. Our STEM training was immediately evident when we first presented our data to a local SoTL audience. We used the third person voice and were stopped in our tracks by an audience member who questioned why if this was our story, being told in our very own words, we needed to objectify it? It became clear to us that even as we embrace the freedom to engage with narrative, we struggle with the fact that it does not come naturally to us.

Dissolving the Dualism of STEM and SoTL

Embracing a complexity approach allowed us to dissolve the dualisms associated with science versus humanities, quantitative versus qualitative, normal versus post normal science. We envisioned normal science as a valuable subsystem within a far more complex intellectual framework:

> It's like looking at Google Earth and only looking at your street for thirty years and then, all of a sudden, … toggling out … and thinking "wow here's another way of telling that" and "oh I can see this is where what I've been thinking … fits"…. It fits … within this whole other way of the world working.

We saw traditional scientific approaches and tools as the means to address certain discrete problems, but coexisting with other approaches that are more applicable for complex problems:

> The …STEM way that I … understand the world is nested within a much larger way of understanding the world that is necessarily messy. … there are times when I can dig into … the STEM grab bag if the problem is

> sufficiently contained. But there are also times when I can't really use this toolset and there's another set of tools that I have to become familiar with.

Dissolving the dualisms allowed us to more freely acknowledge the value of a traditional STEM perspective, a perspective that allows for the organization of amorphous knowledge into manageable predictable frameworks and can provide focused solutions to concrete problems. At the same time, it allowed us to resolve our ambivalence toward embracing a SoTL approach.

Conclusion

Schulman's work on clinical reasoning highlights the importance of *context*, alongside content, in the ability of a physician to reason through the cause of a medical problem (Elstein et al., 1978). His work suggests that clinical reasoning, i.e., medical diagnosis, is not a single trait or skill set but rather, it is learnt within the *context* of a specific body of knowledge, skills and attitude. For example, a physician skilled at medical diagnosis within the field of hematology could not simply transfer that ability to successfully diagnose problems into the field of gastroenterology. Shifting his research to teacher education, Shulman discovered that, in a similar way, teaching is domain specific in that a teacher who can teach one subject might not have the capacity to teach another subject (Shulman, 2002, pp. 7-11). While this might seem obvious, given that content knowledge is key to good teaching, Shulman went further to point out that this is because different disciplines value different forms of evidence, argument, narrative and explanation. In other words, in domain specific teaching, as in clinical reasoning, *context* is key.

If different disciplines have different ways of presenting evidence and argument, not only does this give rise to different ways of teaching and learning but, in a similar way, it gives rise to different ways of inquiring about the teaching and learning of that subject matter. Shulman represents this as differences in *method* and *metaphor*; the historian uses different methodologies to engage in scholarship when compared with the scientist and correspondingly these different scholars use different ways of expressing the results of that inquiry back to their respective discipline specific audiences (Shulman, 2002, pp. 7-11).

We discovered that acknowledging the contexts, methods and metaphors that differentiate STEM from SoTL was a major step on our transitional journey; it allowed us to understand, and accept, the dualisms associated with these differing academic endeavours. Our next step is to extend our conversation to include other 'scholar-travelers' in a series of workshops aimed at addressing the barriers and bridges associated with journeying from STEM to SoTL.

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