CRITICAL INTERDISCIPLINARY DIALOGUES: TOWARDS A PEDAGOGY OF WELL-BEING IN STEM DISCIPLINES AND FIELDS

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ABSTRACT

Students enrolled in Science, Technology, Engineering and Mathematics (STEM) globally and in South Africa are generally not in a state of well-being. International and South African research studies show that undergraduate STEM programmes pose significant challenges to students and that many STEM programmes are marked by high attrition rates and poor student success. There is growing recognition that STEM educators need to teach the “whole student” instead of focussing only on STEM knowledge and skills. In order to teach in a holistic way, university educators themselves need to understand and achieve their own well-being. The article argues that a pedagogy of well-being and its associated concepts of competence, self-efficacy, community and inter-relatedness are key to academic staff and student well-being in the STEM disciplines. The focus of this article is an inter-institution study on enhancing STEM educators’ capacity towards a pedagogy of well-being through teaching portfolio development in diverse institutional contexts. The research question guiding is the study is: How might academic development practitioners and STEM university educators successfully collaborate for the benefit of student well-being and success? Data for this study was obtained from “critical dialogues” between academic development practitioners and STEM university teachers, as well as an external evaluation of the project. The data comprise video-recordings of the critical dialogues and survey responses. The findings of the study indicate that there are barriers as well as productive spaces for interdisciplinary work towards well-being in STEM teaching and learning. The findings have implications for how STEM academics might engage in professional learning towards pedagogical competence, and offer suggestions for the ways in which academic developers might respectfully "transgress" into STEM disciplinary domains in support of a pedagogy of well-being in the STEM disciplines and fields.

Keywords: pedagogical competence, STEM disciplines, interdisciplinary collaboration

INTRODUCTION: PROFESSIONAL LEARNING AND WELL-BEING IN STEM DISCIPLINES AND FIELDS

Well-being in education has been a matter of concern for many generations of educational philosophers and theorists (e.g., Dewey 1916; Maslow 1943; Rogers 1979). In higher education, well-being was brought to public attention by Bowen and colleagues in an early study of the purposes of higher education (Bowen et al. 1977), re-published in 2017 (Bowen 2017). The need for a new edition of this work speaks to the currency of well-being as an ongoing concern amongst university educators. Bowen and colleagues (1977) critiqued the economic agenda that was (and still is) driving higher education, and argued instead for a deeper understanding of education as the development of the "whole person". Recent studies have followed the tradition of placing students' well-being at the centre of higher education (Harward 2016). Well-being in higher education is understood as eudaimonic, that is, not in terms of generic wellness, but as growth towards competence, professionalism and excellence within a field and, with the support of others, developing a sense of agency, autonomy and self-efficacy. Such collegial support enables a sense of "relatedness" and the building connections within communities of teaching, learning and research (Ryff 2014; Ryan and Deci 2002; Lauermann and König 2016).

Within the STEM fields in higher education, wellness studies have tended to focus on diversity and inclusivity in the STEM disciplines (Kilgore, Sattler and Turns 2013), socially just pedagogies (Leibowitz 2017), and the orientation of STEM graduates towards "public-good values and with commitments to making professional contributions to society which will advance human well-being" (Walker 2015). In this article we argue that students' well-being in the STEM disciplines is dependent on university teachers' willingness to shift from a narrow focus on disciplinary knowledge and technical skills towards an educational vision that encompasses the whole student. While students' difficulties in mastering STEM knowledge are acknowledged, there is growing recognition that students' engagement with complex STEM disciplinary knowledge, and their well-being in this engagement, is strongly supported when the academics who teach them are pedagogically competent to do so (Tenenberg and McCartney 2010). Lauermann and Konig (2016) explain that teachers' professional competence "is a critical predictor of teachers' professional wellbeing". Several studies confirm that competence, or "the need to feel confident in doing what one is doing" (Ryan and Deci 2002) is a key factor in well-being. There are a cluster of concepts related to "competence", such as "relatedness", and the need to have human connections that are close and secure, and that build and respect autonomy while facilitating competence (Gagné and Deci 2005). In higher education, an important aspect of well-being, from university teachers' perspectives, would be the attainment of pedagogical competence and meaningful relationships with colleagues and with students.

The means available to STEM educators to achieve a pedagogy of well-being is through collaboration with colleagues, such as academic developers, whose work has focussed more directly on the "whole student". While most STEM university teachers have learned successfully in a traditional format, they are the exception, rather than the norm. University teachers globally are increasingly required to meet standards of pedagogical competence, with regard to accurate and up-to-date knowledge within their subject area, as well as knowledge of subject-based teaching and student learning, including online or blended learning modalities (Olsson and Roxå 2012). A pedagogy of well-being assumes such pedagogical competence, but moves beyond this to include knowledge of students, a desire for the well-being in the discipline or field, a reflective and critical approach to teaching, engaging in professional learning and increasing pedagogical expertise over time, drawing on pedagogical research in the subject area. Such a pedagogy is strongly tied to an academic's professional role and identity.

The focus of this study is on the practices that contribute to successful collaboration between Academic Developers and university STEM teachers for the purpose of university teachers' and students' well-being. The specific research question guiding is the study is: How might academic development practitioners and STEM university educators successfully collaborate for the benefit of student well-being and success?

BRIEF OVERVIEW OF THE LITERATURE: STEM PEDAGOGICAL COMPETENCE AND EUDAIMONIC WELL-BEING

Significant resources have been invested in STEM education world-wide in an effort to increase the number, quality and diversity of graduates, but these investments have not resulted in widespread adoption or systemic transformation (Mckenna, Froyd and Litzinger 2014). The lack of uptake of professional learning opportunities amongst academics has been attributed to the need to improve the alignment between STEM educators' researcher and teacher identities (Roxå, Mårtensson and Alveteg 2011), to STEM academics' difficulties with educational research and theory (Roxå, Olsson and Mårtensson 2008), and the challenges of changing entrenched teaching and learning practices. The teaching portfolio has emerged as a way to achieve systematic and scholarly teaching by drawing on teachers' reflections on, analyses of, and responses to their students' learning. A teaching portfolio could be seen as a pivotal point around which the academic well-being of both staff and students could be built (Kilgore, Sattler and Turns 2013). Professional learning toward the development of a teaching portfolio can address a range of issues, from effective classroom teaching, exploring disciplinary modes of inquiry and reflection, enhancing professional and industry connections, linking with wider teaching communities, and making connections with other institutions and groups. Teaching portfolios tell "stories" of teaching that draw on the resources of educational research, but also take learning across disciplinary boundaries to be assessed by colleagues (Olsson and Roxå 2012). Teaching portfolios are commonly used to demonstrate evidence of growth, competence or the attainment of excellence – all of which are strongly linked to eudaimonic well-being (Ryff 2014). Promoting and assessing student learning and acquiring a repertoire of teaching practice is underpinned by an understanding of educational theory, by reflection on practice and by classroom-based research. The literature on pedagogical competence and how this might be developed suggests that teaching portfolios, and supportive collegial processes of portfolio development, are powerful ways of enhancing eudaimonic well-being amongst university educators and students.

Several South African, and many international universities, require academic staff to present teaching portfolios when applying for tenure, promotion or teaching excellence awards. Teaching portfolios are thus important artefacts that have come to symbolise transitions in an academic career, in particular the transformation of teaching practice. Teaching portfolios thus play an important role in the attainment of pedagogical competence, and as such create a space to foster educator well-being. Despite the potential of teaching portfolios to contribute to well-being, in higher education, the difficulties that educational concepts and terminology pose to academic staff in STEM disciplines could have the unintended consequence of causing alienation and disconnectedness. As theoretical approaches to teaching and learning are often unfamiliar to STEM academics, it is helpful to facilitate conceptual changes among STEM academics by appealing to a basic understanding of pedagogical theory in a way that is recognisable to scientists and engineers. Recognising connections through such illustrative models could simplify educational concepts and help STEM academics understand the pedagogical processes needed to understand student learning and their roles as facilitators of that learning.

Theoretically framing the interdisciplinary dialogue

To enable productive interaction between academic developers and STEM university teachers, it is important that each group understands something of the "life-world" of the other. We draw on the explanatory power of Legitimation Code Theory (LCT) to understand key differences between Academic Development as a field and the STEM disciplines and fields. LCT arose from a need to understand the complexity of different forms of knowledge, and the kinds of "knowers" that develop in different disciplines and fields (Maton 2014). There are many LCT tools; in this article we use the dimension of Specialization. Specialization provides a means of studying practices that differ in the emphasis placed on the role of "knowledge" and "knowers" across disciplines and fields. Maton explains that "practices and beliefs are about or oriented towards something and by someone" (2014, 29). This is captured as a Cartesian Plane (see Figure 1).

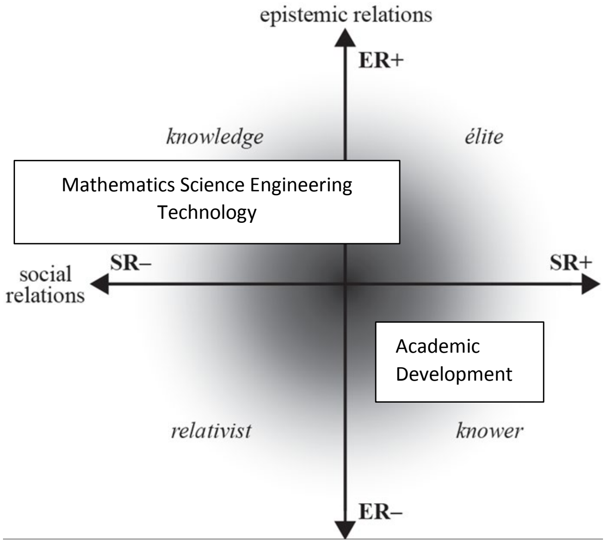

Figure 1: The Specialization Plan (adapted from Maton 2014)

The vertical axis describes how strongly teaching is governed by disciplinary knowledge. The horizontal axis is about the strength of the relationship between the people and their practices – in the context of this study, the teaching and learning relationship.

We place Academic Development in the "Knower" quadrant because its practices draw on the disciplines of sociology and cognitive psychology. These disciplines have a strong social relation, based on "the virtue of academic, non-professional education" (Muller 2014). Following the traditional Humboldtian view of university "the moral order [of Academic Development] stresses the importance of internal motivation for studies, theoretical work, critical thinking and intellectual growth ... true studying must not be a means to external ends ..." (Ylijoki 2000). This is very different from the STEM disciplines, but what LCT allows us to see, is where the different STEM disciplines might potentially shift towards the social relation. With LCT we can, firstly, disaggregate the STEM disciplines and position them along a continuum across the top two quadrants – from Mathematics and the Pure Sciences in the "Knowledge" quadrant to the applied sciences (e.g., the health sciences), and engineering and technology moving towards the "Elite" quadrant. Mathematics, for example, consists of multiple languages with strong rules governing their procedures (Quinnell, Thompson and LeBard 2013). The natural sciences (e.g., Physics) have a hierarchical knowledge structure that requires the integration and subsuming of preceding concepts (McWilliam, Poronnik and Taylor 2008). Engineering is an applied discipline with its roots in a professional orientation, but "the membership of the tribe is so demanding that it requires years and years of devotion" (Ylijoki 2000). Technology could be oriented to many different fields – computer science, IT, health sciences and so on – each with its own particular orientations and practices.

The specific nature of the separate STEM disciplines and fields could be probed even further to uncover further details about their epistemic relations and social relations. The fact that we have positioned the STEM disciples and fields as having a strong epistemic relation does not mean that there is no social relation. In professional practice all the STEM disciplines would have developed social relations, such as appropriate practices with regard to fellow professionals, clients, patients, companies, etc. All would have also developed social relations with regard to their pedagogical practices (sometimes referred to in the literature as a "signature pedagogy" (Shulman 2005). Table 1 shows how the STEM disciplines differ from one another, but also how much they differ from Academic Development.

Table 1: Epistemic relations and social relations in Academic Development and STEM

	Academic Development	**Science (e.g., Physics)**	**Technology (e.g., Radiography)**	**Engineering (e.g., Mechanical Engineering)**	**Mathematics (e.g., Accountancy)**
Epistemic Relations	Weaker (Sociology and Cognitive Psychology)	Stronger (Physics)	Stronger (e.g., Medical Physics, Anatomy)	Stronger (e.g., Engineering sciences)	Stronger (Mathematics)
Social relations (in the field of practice)	Weaker (in terms of status in HE)	Stronger (e.g., team-based research)	Stronger (e.g., patient care)	Stronger (e.g., client requirements)	Stronger (e.g., professional ethics)
Social relations (in pedagogy)	Stronger (emphasis on the learning and growth)	Weaker (emphasis on mastery of course content)	Weaker (emphasis on mastery of course content and application to clinical practice)	Weaker (emphasis on mastery of course content and application to engineering design)	Weaker (emphasis on mastery of course content and application to Accountancy)

Table 1 shows that there are considerable challenges to interdisciplinary collaboration; Academic Development as a field of practice is quite different from STEM in terms of its weaker epistemic relations to its knowledge base and a stronger social relation to pedagogy.

However, Academic Development has weaker social relations to its field of practice, academic staff development in this case, because academic developers do not usually occupy high level positions or have high status in the university. The STEM disciplines and fields, to different levels and degrees, exhibit stronger social relations in their fields of practice. All STEM professionals are "knowers" in some sense and it is their social relations to the field of practice that could potentially open up spaces for interdisciplinary collaboration towards a pedagogy of well-being. The shaded square, under "Academic Development" is the area of strength that academic developers possess, and need to share with STEM educators in support of student well-being. The shaded areas under the STEM columns are their areas of stronger social relations, and potential openings for collaboration with academic developers.

Developing an understanding of one another's areas and fields is key to developing respectful collaboration. We argue that academic staff development in STEM fields is a form of inter-professional, interdisciplinary learning. We thus draw on concepts from interdisciplinary collaboration to further understand interdisciplinary practices. Interdisciplinary scholars explain that "inter-languages", (Galison 1997), "boundary objects" (Star and Griesemer 1989), "interactional expertise" (Collins and Evans 2015) and "transaction spaces" (Nowotny, Scott and Gibbons 2001) are productive in interdisciplinary collaboration towards shared understanding and practice. An interdisciplinary approach to building pedagogical capacity amongst STEM educators requires negotiation around "boundary objects" (Star and Griesemer 1989) and finding common ground through shared concepts and concerns. Galison (1997) explains that differences in terminology and concepts across disciplines make interdisciplinary collaboration difficult; thus successful collaboration entails, firstly, establishing a "reduced common language, or creole," for communicating across research communities. The first step is thus to agree on the meaning and utility of common terms. Star and Griesemer's (1989) classic paper on interdisciplinary collaboration points to the importance of shared goals (student well-being and success in this case), even though these goals may only be partially shared. The partial sharing might be that all university teachers want their students to experience well-being and to succeed, but may have different understandings of how this is achieved. The partially shared object thus becomes the focus and goal of the interdisciplinary collaboration. Potential boundary objects for academic development and STEM collaboration include concepts such as "Pedagogical Content Knowledge" (Shulman 1987), "Signature pedagogies" (Shulman 2005) and "threshold concepts" (Meyer and Land 2003). Collins and Evans (2015) claim that interdisciplinary collaborators (eventually) develop "interactional expertise", that is they learn a considerable amount about other disciplines, and in the process develop respect for one another's disciplines and discursive practices. Finally, Nowotny and colleagues (2001) recommend "transaction spaces" – safe spaces for collaboration, particularly at the start of an interdisciplinary project.

RESEARCH DESIGN AND METHODS FOR RESEARCHING INTERDISCIPLINARY COLLABORATION

The research question guiding the study is: How might academic development practitioners and STEM university educators successfully collaborate for the benefit of student well-being and success?

Research design

Because the research question for this study involves interdisciplinary collaboration, it was felt that "critical dialogues" that included both academic developers and STEM academics would be productive. A critical dialogue is a conversation "that inspires insight and wisdom on a particular topic, both for the individuals participating in the discussion and the collective thinking of the group" (Karlsson 2001). Data for this study was obtained from three critical dialogues and well as a survey-based external evaluation of the project. The critical dialogues involved in-depth discussions between STEM academics and academic developers. Each critical dialogue included a brief presentation and the posing of questions by a team member; this was followed by the discussions between academic developers and STEM educators. The critical dialogues were video-recorded (with the permission of participants) and constitute the main data source for the study. The survey was conducted by an external evaluator who wrote a detailed report on the survey data. Ethical clearance was obtained for the study by the lead institution, and permission was granted by the partner institutions. Each participant provided informed consent. STEM academics are identified as STEM 1, STEM 2, etc. And academic developers, as AD 1, AD 2, and so on.

RESEARCH FINDINGS: SHARING LANGUAGES, OBJECTS AND SPACES TOWARDS A PEDAGOGY OF WELL-BEING

The research findings from the critical dialogues and survey are presented in terms of 1) the difficulties encountered in collaborations between academic developers and STEM lecturers, 2) existing practices that involve different kinds of interdisciplinary collaboration, and 3) suggestions and recommends for strengthening collaborative work.

Critical dialogue 1: challenges to interdisciplinary collaboration

In the first Critical Dialogue, following a brief input on disciplinary differences between

Academic Development as a field and STEM disciplines and fields, participants were invited to discuss the following questions, with a particular focus on their prior interactions:

1. What kinds of knowledge do you work with and what kinds of knowers would you like to develop?
2. How did you/could you achieve this working with colleagues in other disciplines or with educational specialists?

STEM academics and academic developers shared accounts of their interactions. Both the academic development practitioners and the STEM lecturers described a number of difficulties. Those who attempted interdisciplinary collaboration in their universities attested to the fact that departmental silos are a barrier to educational and disciplinary interaction; as one participant put it: "academics generally don't talk across silos" (STEM 1). As anticipated by Gallison's (1997) work on the need for a "common language", STEM lecturers explained their struggles with educational texts. As one participant complained: "some terminology, I still don't get" (STEM 2). In the survey data, the discourse of teaching and learning was highlighted as a particular challenge, with the more formal terms, such as "pedagogy" and "epistemological access" causing considerable confusion. STEM lecturers struggled with the ways in which educational texts were written, as these differed from the texts to which they were accustomed. A STEM participant explained that "reading [educational texts] at an advanced level was challenging as ... one had to research a concept before continuing to read" (STEM 3). A STEM lecturer shared his frustration regarding the lack of accessible literature on teaching STEM disciplines. STEM academics attempted to "grapple with the various [educational] concepts" (STEM 4), but found educational theories "tricky" (STEM 2) and terminology like "critical reflection" (STEM 5) was challenging.

As part of the reflective discussion an academic developer commented that she had "underestimated the level of challenge posed to STEM lecturers in mastering the basics of educational theory and practice" (AD 1) in a context where, as a STEM lecturer put it, "everything is all new material ..." (STEM 5).

A STEM lecturer who had completed a Postgraduate Diploma in Higher Education (PGDHE), spoke of the resistance among colleagues towards attempts at transforming pedagogy. They seemed to have "another view of themselves as teachers [that] they regarded as good for themselves" (STEM 6). As a scientist, his ideas about pedagogy had changed, owing to the PGDHE, but it was difficult to convince others who were "opposed to alternative ways of doing and seeing education, because their perspective required evidence". Ironically, when asked to explain poor student results, they were unable to do so. They refused use educational research and theory to improve their students' success and resisted ideas that he offered from his PGDHE experience. It was a very challenging situation for him.

An Academic Developer was concerned about how STEM academics used their relationship with professional bodies to "cop out" (AD 5) of professional learning opportunities: "ECSA [the Engineering Council of South Africa] says I can't" (AD 5) – when the professional council was irrelevant to improving one's teaching. This kind of reasoning revealed more about the unequal power relations inherent in the relationships between academic developers and STEM academics, with the latter able to exercise agency in how and what to teach. Academic developers needed to be aware of this and be more strategic, consistent and agential.

Many STEM academics felt that there needed to be more STEM content in the professional learning programmes facilitated by academic developers:

> "We did not hear much about discipline-specific teaching ... there are only a small amount of presenters who teach techniques that I could relate to." (STEM 4).

Even when general educational ideas was found to be useful, the STEM participants felt that disciplinary input was necessary: "[Teaching and learning workshops] are useful, but I also missed someone in my discipline who shares some of the same constraints" (STEM 5).

Academic Developers too described some of their challenges. An Academic Literacy specialist shared his experience of doing academic literacies work in disciplines where "not only academics but students were resistant to deviations from traditional practices" (AD 1). The Academic Literacy specialist explained that he was trying to identify the origin and nature of such resistance, so he could take the initiative to begin a process of overcoming these barriers.

Critical dialogue 2: Shared objects and safe spaces

Critical dialogue 2 comprised critical reflections on participants' more positive interdisciplinary practices and collaborations. While there was a general understanding that academic development practice is grounded in social science values, in fact most AD practitioners work in interdisciplinary spaces, and have developed a degree of "interactional expertise" (Collins and Evans 2015). They had, for example, introduced academic staff to useful disciplinary concepts, such as "threshold concepts" (AD 5) and "concept mapping" (AD 2). Some institutions had AD units located within faculties that supported collaboration between educational and disciplinary specialists – and several departments valued such collaborations.

An academic development specialist commented that "crossing disciplines" was inherent in the job of academic development (AD 7). The STEM academics with whom he worked "had reasons for how they teach" (AD 7). He had found that, if he was to influence their thinking, he had to learn "to understand their world view first", because that was "the point from which their collaboration could begin" (AD 7).

Another academic developer regarded his role as needing "to teach lecturers to teach" while recognising that academics were "experienced in assessment in their individual disciplines ... thus were not 'blank slates' ... and [he] allowed participants to reflect on their own practices and adapt these where applicable" (AD 8). He questioned how to "give a voice" to those academic developers "working in interdisciplinary spaces, straddling departments and disciplines ..." (AD 8). He believed such individuals, along with STEM academics, had a significant role to play in defining pedagogical competence in STEM.

An academic developer with a background in the natural sciences explained that she straddled two disciplines: her own and teaching and learning. She had to therefor keep asking herself "is one side critiquing the other side, or vice versa?" (AD 3). She had found that, as a teaching and learning specialist, she was listening much of the time. She explained that she always asked STEM colleagues questions about their practice and then initiated conversations about changing pedagogy, starting with their insights and experience.

A STEM academic stressed that those in academic development needed to ensure they were not apologetic about their work and role, as this gave too much power to those whose pedagogic practices they were trying to develop (STEM 1). Terms like "hard" and "soft" sciences tended to reinforce unbalanced notions (AD 5). Academic Developers needed to draw on their own theoretical perspectives and frameworks in their work with STEM academics, and while STEM academics needed educational knowledge, they did not need to go deeply into pedagogical theory. An academic developer felt that social scientists had a role to play in enhancing STEM academics' pedagogical competence, "because they could identify the difficulties experienced by students ... which their STEM teachers were often unaware of, owing to their tacit knowledge" (AD 1).

Referring to her own experience, an academic developer explained that it had taken her ten years to gain any kind of legitimacy facilitating professional learning in a STEM context. She pointed to the importance of "respecting disciplinary differences, identifying areas that would be productive for teaching and learning", providing useful "tools" for STEM staff, and always behaving "professionally" (AD 5).

STEM academics found many areas for collaboration. A STEM academic explained that "many STEM subjects have a philosophy base, while humanities, e.g., art, music ... etc. can have a maths or science base" (STEM 1). An Applied Mathematics lecturer explained that he used music (including rap!) to teach statistical concepts as the course content was generally "extremely boring" for students and the music "livened things up" (STEM 9). Several STEM academics who has attended a PGDHE or other short courses found themselves developing educational "interactional expertise" in pedagogy. As a STEM academic explained:

> "It's been so long, but ... I remember feeling the elation of insight into the education field, coupled with the stress of a massive steep learning curve ...." (STEM 6).

Critical dialogue 3: developing "interactional expertise"

The third critical dialogue focussed on how interdisciplinary collaboration – with the shared object of student well-being and success – might be taken forward. The intention had been to discuss teaching portfolios, but a key issue arising in this critical dialogue was around strengthening academic development practice. It was acknowledged that academic development did not enjoy a particularly high status at most universities and that "recognised power and control ... institutional structures [were] reflected in academic staff development dynamics" (AD 5).

The advice of STEM academics to academic developers revealed interesting insights. Firstly, in order to achieve respect in STEM disciplines, academic developers "need to understand the STEM world-view" (STEM 2). Secondly, "Academic Developers should be more 'scientific' in terms of the science of teaching and learning" (STEM 4). The issue was again raised about the need for more STEM in STEM pedagogical training. Educational terms might need to draw on the discourse of STEM and be "translated" to make them more meaningful to STEM academics (e.g., "design review" instead of "critical reflection"; "re-engineering the curriculum" instead of "re-curriculation"). Academic developers could also consider alternative images outside both the context of STEM and that of teaching and learning with which both parties could identify, such as the notion that teaching is "like cultivating the ground: one has to sow the seed, as well as weed; one needs water and sun" (STEM 7). This could lead to productive discussions of individuals' ideas about the nature of education.

Collaborative educational research provided opportunities for collaborative interdisciplinary work between academic developers and STEM academics. Through working as co-researchers, STEM academics would develop more respect for educational theory (even if they did not understand it).

Both academic developers and the STEM educators felt that it was inevitable that there would be resistance in the transition from STEM to education, but that this could be minimized if both “both STEM lecturers and AD practitioners had clear roles to play in defining STEM pedagogical competence” (STEM 8).

STEM academics believed that academic developers “needed the voices of STEM academics who had noted positive changes to their practice during the process of developing a teaching portfolio” (STEM 3), or engaging in professional staff development. They would be “invaluable in encouraging other STEM teachers and offering them advice” (STEM 5). Such collaborations could be on a small-scale initially: “We need willing partners across disciplines ... it can often take only one person to start” (STEM 3). Sharing experiences of being “an inter/multi-disciplinary person ... sometimes an outsider, sometimes and insider ...” (AD 5) could also be useful. It was important to have “AD and STEM-conversations ... with a lot of listening” (STEM 2).

Other issues raised were that STEM teachers working on portfolios would develop links with one another as well as with academic developers to create a “community of practice” (STEM 8). Such regular conversations would serve to build teaching and learning in the context of STEM subjects. One of the sources of difficulty (and resistance) amongst STEM lecturers to changing their teaching and learning practice was general suspicion of what counted as “evidence” in educational practice, for example, what counts as evidence of student improvement following a particular intervention. To address this, Academic Development need more credibility, “more backup, more consistency ...” (STEM 9). Finally, there was a need for academic developers to assert their expertise. For example, academic development practitioners, “even acknowledged curriculum experts are generally not consulted on STEM curricula” – when bringing their expertise into curricular renewal would be of benefit to faculties, educators and student (STEM 10).

ANALYSIS OF THE CRITICAL DIALOGUES

In Critical Dialogue 1, there was evidence of “code clashes” (Maton 2014) in the encounters between the STEM academics (with stronger epistemic and weaker social relations) and academic developers (with their weaker epistemic and stronger social relations). These “code clashes” played themselves out as “war stories” and general feelings of alienation and discomfort in one another’s disciplinary spaces, the opposite of well-being. In Critical Dialogue 2 some common ground was found towards developing “interactional expertise” amongst interdisciplinary collaborators. The academic developers shared their developing understandings of the STEM disciplines and fields in which they worked (i.e., strengthening the epistemic relation), while STEM academics explained how they were taking on some of the values of practices of pedagogies of well-being, even experimenting more creatively (thus strengthening the social relation). In Critical Dialogue 3, the STEM educators offered advice and recommendations to academic developers on how they might go about increasing their legitimacy in STEM contexts (which was, of course, by strengthening the epistemic relation of their own disciplinary base). The critical dialogues thus facilitated STEM academics and academic developers' sense of "relatedness", of supporting one another around the common goal of ensuring students well-being and success.

The difficulties that academic developers and STEM educators experienced with one another's disciplinary practices suggested that what was needed for successful interdisciplinary collaboration was for both STEM university educators and academic developers to develop "relatedness", or in the language of interdisciplinary collaboration, "interactional expertise", such as developing an awareness of the practices and norms of each other's disciplines and fields. In more successful collaborations, academic developers recognised that there were alternative epistemic and social relations and sought to understand the nature of STEM knowledge production and professional practice. STEM academics learned about reflective teaching practice, and began to appreciate its value for improving student success. Through the critical dialogues, colleagues began to realise the necessity of possessing at least some knowledge about the other field, which simultaneously enabled them to build a meta-disciplinary awareness of their own knowledge-base for the purposes of effective collaboration. The Critical Dialogues were effective ways of developing interactional expertise.

Galison (1997) explains that developing an "inter-language" for the productive exchange of ideas in interdisciplinary work is an essential first step. The critical dialogues inspired the project team to make an attempt at this (see Table 2). "Translating" from one discipline to another is not a mechanical process; it involves translating a world-view, and appreciating the contribution of different disciplines. Because disciplines differ in fundamental characteristics, such as how knowledge is created, what counts as acceptable data, or how one presents work done in different fields, interdisciplinary research and collaboration will be strengthened by helping collaborators to identify, explore, and negotiate disciplinary differences. Academic developers need to understand some of the difficulties that STEM academics encounter, such as unpacking threshold concepts in the STEM disciplines and discovering ways of teaching these that will support students' growth and well-being. For example, in pure mathematics the concept of a limit is a generally recognised threshold concept; it is the gateway to mathematical analysis and constitutes a fundamental basis for understanding some of the foundations and applications of other branches of mathematics such as differential and integral calculus (Meyer and Land 2003). Mathematics lecturers know this tacitly, but they need to know it explicitly. Academic developers can provide a language of description for such tacit knowledge.

Academic developers also need to understand and appreciate the signature pedagogies that have evolved over time by generations of STEM teachers. Quinnell and colleagues (2013) explain that signature pedagogies are a method of teaching that mimics "the professional discipline as students follow the scientific method to demonstrate and enhance their understanding of scientific phenomena". Inquiry-based instruction very clearly engages students "to think and act like scientists" (Crippen and Archambault 2012) and design reviews enable students to "to think like engineers" (Streveler et al. 2008).

These approaches to teaching and learning are tacit for STEM educators, but the theoretical approach and discourse of describing them are often unfamiliar to STEM academics. It is therefore helpful if academic developers are able to facilitate conceptual changes among STEM academics in their roles as teachers by appealing to a basic understanding of pedagogical theory set out in a format that is recognisable to scientists and engineers. Recognising connections through more familiar disciplinary constructs could simplify and help STEM academics understand the kinds of complex pedagogical processes needed to understand student learning and their roles as facilitators of that learning. Table 2 is a first step towards realising this.

Table 2: Translating teaching and learning concepts into stem disciplines

	Mathematics	**Science**	**Engineering**	**Technology**
Disciplinary examples	***Pure Mathematics***	***Physics***	***Mechanical Engineering***	***Radiography***
Constructive Alignment	Alignment of Mathematical competencies and exercises	Alignment of content standards and instruction	Implementation of requirements	Outcomes and methods
Threshold concepts	Limit	Newton's Laws	Thermodynamics	Inverse square law
Student engagement	Practice	Peer Instruction	Project team, design critique	Health science team
Signature pedagogy	Formulate, apply method, prove, solve, argue	Inquiry-based learning	Design, experiment, evaluate, redesign	Clinical round
Discourses	Numerically based texts	Laboratory report, "fast" texts (short, to the point)	Structured (use of templates), graphical	Medical terminology, patient reports
Assessment criteria	Exercise-based (short marking memo)	Explain, provide evidence	Brief and specifications	Case details, patient history
Student evaluations	Appraisal	Feedback	Debriefing	Improvement
Theory	Logic/proof	Evidence	Confirmation/explanation	Evidence-based, Clinical Reasoning
Critical reflection	Check and correct	Assess and revise	Review and redesign	Reflective practice

CONCLUSION: TOWARDS STEM PEDAGOGICAL COMPETENCE

The focus of this study has been on the practices that contribute to successful collaboration between academic developers and university STEM teachers towards building a pedagogy of well-being in the STEM disciplines and fields. We have come to the view that trying to define pedagogical well-being generically for all disciplines or work groups might not make sense, as pedagogies emerged from the critical dialogues as being more discipline-specific; as one of the academic developers expressed it: "My thoughts here is that STEM is too wide, there is no single STEM pedagogical competence" (AD 5). The academic developer explained that "teaching competence in areas of one field, such as biology, might resonate more with teaching competence in another field such as Psychology rather than Physics" (AD 5).

We conclude that STEM university teachers need more support for the difficult concepts that they are required to teach, and agree with our STEM colleagues that there needs to be more STEM content in professional learning facilitated by academic developers. Focusing STEM academics' learning on their own disciplines and fields is likely to enhance both their own and their students' learning and well-being. Thus academic developers need to find out more about these fields and engage their STEM colleagues about what it means to teach in them. In this regard, teaching portfolios are potentially meaningful to STEM academics because they enable a focus on the STEM academics' specific subject areas and practice (rather than on generic themes in teaching and learning). The study proposes a framework for re-conceptualizing academic development in STEM contexts, understanding professional learning as an extension of the critical dialogues that we have had with STEM colleagues. Insights gained from these findings could potentially strengthen the quality of teaching in STEM disciplines and fields, and ultimately benefit the students, the "whole persons" whom we serve.

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