Learning Across Discipline Boundaries Through Narrative Inquiry: A Study of a Collaboration to Improve Mathematics Teacher Education[1]

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Improving mathematics education is an issue that arises periodically in the media and is the object of frequent, and sometimes contradictory, policy efforts and academic endeavours. Strategies used to tackle this issue range from raising requirements for tertiary entry to focussing on innovative pedagogies. One strategy with the potential to enhance pre-service teacher education is to improve collaboration between the stakeholders charged with providing this education: mathematicians and teacher educators. However, finding ways to enhance collaboration across discipline boundaries remains largely unexplored in this context.

This paper studies the development of a multidisciplinary team of university academics collaborating to improve mathematics pre-service teacher education. To facilitate this collaboration and shared learning, a narrative inquiry process was utilised. The process enabled members to explore, deepen and sustain their connections with one another and their understanding of the shared focus underpinning their work as teacher educators. Our thematic analysis of the narratives obtained, highlights factors that enhance or potentially hinder multidisciplinary interactions and learning. Multidisciplinary teams may use their increased knowledge of these factors, and the process of narrative inquiry itself, to reflect upon their current and future collaborations. This allows such teams to preclude, manage, and respond to challenges in ways that can ultimately enhance pre-service teacher education.

Keywords: boundary encounters · narrative inquiry · multidisciplinary collaboration

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Introduction

The preparation of mathematics teachers involves the participation of a diverse range of stakeholders ranging from government and regulatory bodies, schools and tertiary institutions, and the students themselves. At our tertiary institution, a regional institution in Australia, the key stakeholders involved in teacher preparation at the undergraduate level are mathematicians and teacher educators. The roles played by these two stakeholders are clearly distinguished; while mathematicians provide pre-service teachers with mathematical *Content Knowledge* (CK) for approximately one third of the time in the four-year degree, teacher educators tend to focus more on *Pedagogical Content Knowledge* (PCK) (Shulman, 1986) for approximately one eigth of the time[2]. It was believed that it would be potentially beneficial that, in order to improve pre-service mathematics teacher education, we harness both discipline expertise and pedagogical expertise simultaneously; a multidisciplinary collaboration (Goos, 2015).

A successful multidisciplinary collaboration requires a group of people from diverse disciplines working together synergistically to achieve common goals (Vanasupa, McCormick, Stefanco, Herter, & McDonald, 2012). In pre-service teacher education, the group usually consists of a team of academics with backgrounds in different knowledge bases who have developed a language (specific terminology and ways to communicate) most accurately interpreted and understood by those within their own discipline (Boden & Borrego, 2011; Hall, 2005; Seethaler, Czworkowski, Remmel, Sawrey, & Souviney, 2013; Waitoller & Kozleski, 2013). Examples of this language in our research can be found in expressions such as *student-centred pedagogy*, *problem-solving*, or *critical thinking* that were used to communicate within teacher education but were often not widely used in the other discipline.

There exists a wealth of research on the interaction within multidisciplinary teams (Duffield, Olson, & Kerzman, 2013; Schaffer, Lei, & Paulino, 2008), and also how these teams can learn together as a consequence of this interaction (Wenger, 1999). The work of Wenger (1999) draws attention to multidisciplinary teams when he refers to the boundaries that exist between locations within large organisations with shared histories. He states that a close focus on these boundaries, which in the context of this study could include boundaries between disciplines, can have significant benefits.

The research presented in this paper focused on developing an understanding of how reflections on interactions and learning within a team can support their work to achieve common goals in the context of a community of practice across discipline boundaries. The research was embedded within a larger national project aimed at improving teacher education in the sciences and mathematics. This larger national project had several aims, and our inquiry sought to contribute towards the first one of those, namely "to foster genuine, lasting collaboration that unites mathematics, science and education scholars across disciplinary boundaries that have previously divided them"[3] Using a narrative inquiry process to facilitate collaboration for the members of this team, our aim was to draw insights into the factors that may enhance or hinder the interactions and learning essential for the success of multidisciplinary collaboration.

[2] The rest of the degree is comprised of *Pedagogical Knoweldge* (PK) subjects such as psychology and sociology of education, and three practicums.

[3] More information about this project can be found in https://imsite.newcastle.edu.au/

Literature Review

Interacting in Multidisciplinary Teams

The complex social relationships required for multidisciplinary work develop when participants undertake meaningful activities and genuine practices together. Useful interactions are crucial for these activities to occur (Wenger, 1999).

Factors identified in the literature that work against successful and sustainable multidisciplinary collaboration include poor communication, consultation, voice, or feedback (Carroll et al., 2014; Duffield et al., 2013; Vanasupa et al., 2012; Wenger, 1999); a hierarchical structure of teams (Borrego, Boden, & Newswander, 2014; Duffield et al., 2013; Hall, 2005; Vanasupa et al., 2012); being too close or too distant and therefore lacking opportunity for independence and interdependence respectively (Borrego et al., 2014; Wenger, 1999); and a culture that necessitates protection of self and one's work (Duffield et al., 2013).

Attributes such as humility, trust, openness, and tolerance of diversity support more positive and productive interactions in multidisciplinary teams (Carroll et al., 2014; Duffield et al., 2013; Ness & Riese, 2015). Carroll et al. (2014) stated that teams whose contact together is only transient and fragmented are not undertaking *real* multidisciplinary team work. Across disciplines, a better understanding of why there may be "unexpected interpretations of events, actions, statements or documents" can be critical to successful interdisciplinary work (Wenger 1999, p. 254).

Learning in Multidisciplinary Teams

With a focus on the boundaries as understood by Wenger (1999), there is potential for greater learning, innovative problem solving, and the emergence of new knowledge and practices. Wenger's (1999) work on the ways people see and work together reveals that groups operating as a community of practice provide an environment for both innovation and sustainability. What distinguishes these working groups from other groups is that they have the capacity to take active control of their own learning, leading to the development of shared practices. These practices further enhance the learning and motivation of the group toward sustainable productive relationships. In the case of this research improving mathematics teacher education may be as much about discovering how teacher educators learn in a community of practice across discipline boundaries as it is about improving pre-service teacher education per se (Goos, 2014).

The skills to operate effectively as a community of practice have been considered throughout this study. Wenger (1999) categorised them as: deep engagement with the *object* and *subject*, a balance between planned and opportunistic learning, transformative experiences across fields that are broad without losing depth, and the maintenance of alignment and relevance. However, learning, performance, and motivation can be adversely affected when a team has insufficient support (Borrego et al., 2014; Schaffer et al., 2008; Seethaler et al., 2013; Vanasupa et al., 2012; Wenger, 1999). Also important to facilitate learning are conflict, healthy debate (Vanasupa et al., 2012) and critical, candid conversations (Duffield et al., 2013). The gradual development of a transferable hybrid language enhances accessibility to all (Dillon, 2008), and the development of a space where neither discipline dominates enables a new collective understanding to emerge (Vanasupa et al., 2012).

Wenger (1999) points out that it is possible that members of the community of practice will have a shallow understanding of the hybrid language even though they might use it, and even after exposure to aspects of the other discipline's practice. According to Wenger (1999), for deeper, more meaningful learning to occur, a pedagogical approach is required that uses authentic learning experiences. For these learning experiences to be authentic, they need to be based on activities that are typical of how the relevant knowledge would normally be used or applied. For those who are new to these types of activities and this way of learning, it will require them to deliberately apply knowledge to a particular context, often employing a different way of thinking and rendering the experience meaningful.

A balanced focus on both process and product is also necessary for the success and sustainability of learning in multidisciplinary teams (Vanasupa et al., 2012; Waitoller & Kozleski, 2013). This means moving beyond focusing solely on discipline knowledge to building a greater knowledge of oneself and others in the context of the multidisciplinary work. There needs to be an opportunity for assumptions to come to the surface, for these may constrain the ability to work together (Waitoller & Kozleski, 2013). Such opportunities also help team members to better understand what is important to others and, therefore, possible approaches to take. The ability to understand other people's motives aids multidisciplinary work (Ness & Riese, 2015). Not making connections between team members' values and the aims of the project can result in disengagement (Vanasupa et al., 2012).

A willingness to co-evolve with the project, study oneself, conduct research on one's own thoughts and actions and the impact they have, and then apply this learning, is important for the success of multidisciplinary relationships (Vanasupa et al., 2012; Waitoller & Kozleski, 2013). A clear example of the consequences of not doing this is described in the work of Vanasupa et al. (2012) with respect to the failure of their collaboration across faculties in a tertiary institution. They concluded that it was not the obstacles themselves that led to the failure of their work together, but the lack of their examination of those obstacles. They recommend strongly that team members work to develop a high level of self-awareness and self-reflection through processes that examine the intentions and expected outcomes of all team members.

Methodology

The exploration of multidisciplinary collaboration presented in this paper has utilised a narrative inquiry process (Daiute, 2013) to collect data and a thematic analysis process (Riessman 2008) to analyse the data.

Narrative inquiry aligns well with work of a multidisciplinary nature because it naturally traverses disciplines and is multi-vocal (Andrews, Squire, & Tamboukou, 2013). Theoretically and methodologically the use of narrative for research is broad and diverse, perhaps blurring the boundaries between the quantitative and qualitative, which has led to disagreement throughout its development as a tool for research (Riessman, 2008). Yet this has been balanced by the many strengths this diversity provides, such as its ability to be used for a greater variety of purposes (Daiute, 2013). Some of the benefits of narrative work listed by Daiute (2013) include: its potential to reveal deeper levels of understanding (which surveys may be unable to achieve); its ability to empower the voices and perspectives of any who have been silenced or excluded; its ability to explore complexities and their interactions sensitively (e.g. intercultural interaction and the plurality of experiences); as well as its ability to provide a sense of affirmation to those involved.

Narrative inquiry process

The multidisciplinary team of seven academics participating in this research commenced their collaboration in January 2014 as part of a national project to improve teacher education in mathematics funded by the Office of Learning and Teaching [4]. The team met weekly until April 2017 with the objective of working on concrete strategies that could contribute to this improvement. These strategies have been (and continue to be) negotiated and implemented at a medium-sized tertiary institution in Australia.

The multidisciplinary team consisted of education, mathematics and statistics academics. Initially the team aimed to use narratives to explore the team's collaboration as individual contributions, and to examine which aspects of the negotiation of each team member needed to be considered to achieve the common goal of improving teacher education in mathematics. The use of the term *narratives* and what was understood by a *narrative inquiry process* in the context of the academics participating in this project was problematic and signalled the deep epistemological differences that exist between the disciplines of mathematics/statistics and education. In this paper, the term *narrative* or *narratives* is used to refer directly to the stories, or parts of them, that the team members told through the interviews and written reflections they undertook. The *narrative inquiry process* is used to refer to the research conducted on these narratives and is detailed in the next section.

The project officer, a former science teacher in charge of managing the project, but not an academic or pre-service teacher educator, proposed that the narrative inquiry process developed by Daiute (2013) be used to enable team members to understand each other's perceptions and expectations of their role to support the collaboration. The project officer conducted the interviews and transcribed and de-identified the interview data. The team explored one another's de-identified narratives and reflected upon them, basing the conceptualising of this collaboration upon two main texts: Wenger's (1999) seminal work on communities of practice and Goos' (2015) exploration of a very similar situation in *Learning at the Boundaries*

During the research, the team worked together to explore their emerging community of practice in order to drive their own learning. To further advance this learning, they examined both their own and one another's narratives, then wrote reflections with respect to Wenger's (1999) ideas on collaboration explained in the literature review. A particular emphasis was placed on reflecting and responding to issues that may differ across discipline boundaries such as purposes and goals, culture, structures, assumptions, and most importantly, facilitating boundary crossings. The team then shared these with each other.

The conditions of the interviews and the way the reflections were to be shared were agreed to by the team before conducting the research. These conditions included not discussing the narrative work with each other until after the interviews had been conducted (to maintain independence) and de-identifying the documents including the transcripts of the interviews and the reflections prior to allowing the team members to read them. This ensured confidentiality could be maintained and participants could speak without fear of repercussions.

The activities of this narrative study, implemented over 2 years, consisted of an interview-reflection process:

[4] https://www.education.gov.au/learning-and-teaching

Round 1 – Initial interviews (October 2014)
Round 2 – Written reflections upon reading interview transcripts (Nov 2014 - Jan 2015)
Round 3 – Final interviews (December 2015)
Round 4 – Written reflections on the team's experience of the narrative process (Feb 2016)

After the first round of interviews was conducted, the project officer (now in her role as interviewer) and team members made suggestions for the next stage of the narrative inquiry process. The project officer's suggestions were informed largely by her interpretation of the literature. The suggestions of those interviewed were based largely on their experience with the process to-date. The narrative study thus evolved in a supportive, collaborative and multidisciplinary way, as well as through an amalgamation of theory and practice.

Not only was information from each team member elicited and shared, but there were also questions relating to how this process made a difference to each participant. In Round 3, an examination was conducted as to whether the narrative process itself was experienced as helpful to working together (or in what ways it was not).

Narrative Inquiry Process Instruments

Interview questions

Closed questions directly arising from the literature were developed in order to provide team members with a greater awareness of and opportunity to reflect on the various factors that may influence the success of multidisciplinary collaboration. In addition to these closed questions, complementary open questions were used to elicit information that was more likely to unearth the interviewees' unique insights and ideas, and permit the interviewer to additionally explore more deeply during the interview.

The questions were designed following the guidelines outlined by Daiute (2013). Firstly Daiute brings attention to enabling interviewees to engage in deep reflection and learning, communicate their personal vision, and explore ways of working together. She also highlights the importance of engaging in sense-making, being empowered and provided with a creative opportunity, and being more mindful of what might influence the wellbeing of the team. Observing more closely the interactions and practices of self and others, clarifying the goals and direction of the project, and discovering what works and what does not for this team in the context of this project were also considered essential to increase awareness of factors that may affect the collaboration.

Written Reflection Questions

The questions for the written reflections (Round 2) also had multiple purposes. These questions included a metacognitive element enabling team members to further reflect on both their own and others' expressions from the interviews, generating an "interaction of the planned and the emergent" (Wenger, 1999, p. 266).

The questions for the written reflections were also designed to enable team members to become aware that reading their own and others' narratives may offer useful insights (Andrews et al., 2013; Daiute, 2013; Wenger, 1999). They were intended to reveal reinterpretations or new understandings of other team members' perspectives (Daiute, 2013), draw together the range of perspectives within the team on the purpose and goals of the project (Daiute, 2013), and enable team members to become aware of and observe more closely aspects of the culture of the team that may be beneficial (Andrews et al., 2013). The questions also allowed for attention to be drawn

to possible structures, either in place or required, to enhance the work of the project (Wenger, 1999). Other features that were incorporated were the opportunity to reflect on aspects of the other discipline's ways of working that may have influenced their own (Daiute, 2013), to become more aware of possible tensions and contradictions and reflect on ways to address these (Daiute, 2013; Vanasupa et al., 2012), and to explicitly describe their insights on what might be critical to successful boundary crossing (Wenger, 1999).

Some questions in Rounds 3 and 4 focused on the process undertaken, asking those interviewed to evaluate the impact of the narrative inquiry process on their own learning and the project and how they believe this work could be improved. The goals here included: observing any changes in their own understanding of the possible benefits of this narrative inquiry process, considering the influence of this narrative work on communication and understanding of the project, describing any other benefits they experienced as a consequence of participation in this narrative work, suggesting how the use of a narrative inquiry process within this project may have been further improved, and making recommendations with respect to the possible use of this inquiry process for similar projects in the future.

Analysis and Results

The data collected from the narrative inquiry process consisted of interview transcripts and written reflections. Both inductive and deductive analyses were employed, using narrative analysis methods, specifically thematic analysis (Riessman 2008). Open questions were approached using inductive methods whereas targeted questions were analysed deductively, as we had already hypothesised on possible themes, such as time constraints or trust, based on existing literature. Deep and sensitive repeated readings, whilst simultaneously listening for emerging insights and ideas and "looking beyond the surface of the text" (Riessman 2008, p.13), enabled a dictionary to be built to code the data. This was followed by a thematic analysis that enabled the categorisation of the coded data into the four key themes that emerged: *structures, dispositions, communication,* and *ways of seeing*.

The themes that emerged did so in different ways for the initial and final rounds. However, all four themes appeared distinctively on both occasions. The four themes were subsequently explored and analysed using the same procedure, and a set of subthemes for each theme emerged after examining both rounds together. The themes that emerged across all rounds are summarised in

Table 1.

Table 1
Themes and subthemes emerging from interviews and written reflections

THEMES	SUBTHEMES
1. Structures	▪ Time ▪ Space ▪ Processes ▪ Team configuration
2. Dispositions	▪ Caution, respect, and trust ▪ Beliefs, motivation, and priorities ▪ Openness to learning ▪ Positive conflict resolution
3. Communication	▪ Assumptions ▪ Interpretations ▪ Shared language ▪ Building capacity
4. Ways of seeing	▪ Shared vision ▪ Disciplinary paradigms, and research approaches ▪ The detail and the big picture ▪ Creative risk-taking

The results of this final coding, including quotations that illustrate some of the ideas described by participants are expanded below. A last subsection has been included which relates exclusively to participants' perceptions of the narrative inquiry process itself.

Structures

> Structure, structure, structure. I think that is the main need of the team at the moment. (Participant 1)

Time

The team expressed that the narrative inquiry process enabled them to build in the extra time needed to engage meaningfully. They were also prepared to assess, and if necessary, modify their own behaviours. Although they found the weekly meetings to be the main supportive structure to the project, many were frustrated about the limited time the meetings afforded them and would often "hold back" (Participant 3) on fully expressing ideas. The narrative inquiry process necessitated setting aside time to spend on thinking and reflecting deeply on important aspects of the collaboration, at one's own pace and chosen time. This had the effect of transforming time that would perhaps not otherwise have been used as efficiently.

> The true answer is that none of us have enough time, we are under too much pressure. It's nothing to do with team dynamics, it's got to do with the University wanting everyone to be good at everything all of the time. (Participant 2)

> It's finding time to think and sit down and do things together. Time is a factor. (Participant 6)

The narrative inquiry process "enabled things we would not otherwise have had time for" (Participant 3). These things included the extra time needed to enable all to be heard, to engage in deeper dialogue, and to get to know more about other team members' interests, personalities, strengths and behaviours.

Space

In a similar way, the narrative inquiry process was also described as magnifying the space needed to build strong, creatively productive relationships with other members of the team.

> Running from lecture to lecture with a meeting in between, one may not be in the right headspace to maintain a sustained focus or find their most useful thoughts effectively. Some things develop and evolve differently if given time, such as patience and trust. (Participant 5)

Ideas about the effect of physical space and proximity varied. Some felt the interaction on the journey between disciplines was more productive than being in either. Another experienced greater collaboration when the disciplines were in the same building.

> [Education academics in other universities I have been at] work a lot with the Sciences because they can see each other and, you know, have a coffee over an idea. That is something that may seem minor but actually I think it's not. (Participant 1)

Processes

A key insight of the inquiry was that the goals of the multidisciplinary project were equally important as the processes we would use to achieve them. This dual focus was evidenced in all team members' transcripts.

> I don't know that we are completely on the same page about how to get there (yet) …what is to be done is as important as how it is to be done. (Participant 7)

In the first round of interviews of the narrative enquiry, one of the participants elaborated on the need of structure (in the form of co-created processes) to focus the efforts of the team:

> We need more structure. Because of this bouncing off of ideas we just go off in tangents and that can last for hours. (Participant 1)

Team configuration

Observations about team size reflected what team members believed was already general knowledge: Brainstorming and big decisions were best conducted when all were present. Tasks whose main objectives and structure had been agreed upon by the group were best undertaken by groups of two or three, for greater focus and efficiency.
Many members of the team also put forward how the non-hierarchical nature of the team (all were of the same career status) really enhanced their work together.

> The fact that the group formed organically and without any one person dominating is vital in my opinion. (Participant 3)

> We all have the same status within the university. Somebody has to take the leadership role but it's not a power thing. (Participant 4)

Dispositions

Caution, respect and trust

The need for caution and care in both speech and actions towards other team members was expanded upon in the responses. It was felt that this hesitation had the added benefit of buying time to develop a greater understanding of what was important to other team members. As relationships became established, caution reduced, and ideas and opinions were more forthcoming and free flowing.

> (We) didn't really know the personalities and hence didn't want to step on each other's toes accidentally, everyone wanted to play ball together … there were still those initial stages of trying not to say the wrong thing accidentally. (Participant 3)

It was agreed that respect and trust were built over time, with one pointing out that these factors can determine the degree to which team members will participate, cooperate, contribute, and share.

> Was interesting how we (felt) we (had) to prove ourselves as worthy to the (other discipline). (Participant 6)

> We respect each other's expertise and that is not always the case between the disciplines at large. (Participant 2)

The narrative inquiry process also necessitated a tolerance of uncertainty as the process itself was not fixed and evolved over time. The responses of some team members showed the degree of uncertainty they had about this narrative inquiry process and its potential impact, yet they persevered despite this.

> I'm not sure if [the narrative research is] an obstacle but it seems we have been very disparate in our thinking and how to progress, we have sort of spread ourselves perhaps too thinly at times […] The benefits far outweigh the obstacles, because in isolation it is hard to develop ideas and or to even have sounding boards and you go and do the one offs with people whereas with this group you are able to have that group sounding board at times and so you can operate at a potentially higher level. (Participant 3)

Beliefs, motivations and priorities

All expressed an authentic desire for the success of the multidisciplinary project and its outcomes, yet there was some variation in beliefs and motivations. The motivations for some were more focused on career progression, whilst others focused more exclusively on the desired outcomes of the project. The sharing about beliefs and motivations appeared to be of great value to the team, allowing them greater awareness of their assumptions. One member remarked that the narrative work enabled each member of the team to develop a greater understanding of other team member's needs, values and priorities.

> It has made for better mutual understanding of each other and our motivations, which I believe has meant we work from a common perspective. (Participant 5)

The interviews also revealed that the design of a project, and the degree to which the activities within it could be aligned to the requirements for career progression within the university environment, was a crucial factor toward enabling full and unfettered participation of some team members, as it shaped their priorities and motivations.

> In the worst case, if the university keeps us too busy to think all of the time then all of this … will come to very little. We really need to be able to think and reflect and act and it is so hard when people are under the pressure they are under. (Participant 2)

Openness to learning

The willing participation of all team members demonstrated this openness to learning and although at times things did not sit comfortably, they persevered and trusted in the process.

> So, I guess I don't want to speak on behalf of the other (discipline) because I don't see them as others, although I see them as experts in their space. (Participant 6)

Many said that this activity enabled them to reassess prior judgements, conclusions and interpretations involving team members and aspects of their work together. They felt they had developed a greater understanding of, and ability to work with, diversity, referring to things such as sensitivity and patience as well as an understanding of the impact of diversity.

> Each interview represented a view of the project from a slightly different angle: organisational, vision, pedagogical, practical, in a way that reflects the diversity of the group, but not in a grossly incompatible way. (Participant 5)

The questions that sought to raise awareness of factors that may affect multidisciplinary work, were of immediate benefit to some team members, who may not have considered the possible effects of these factors previously.

> Oh yes, I guess I do, the more I think of it [the more evidence I see that this factor has influenced our work together]… (Participant 6)

Positive conflict resolution

The possession of attributes such as respect and trust however will not mean there is no conflict or that conflict should be avoided. Members felt it was a normal part of their work together and could be healthy.

> Everyone seemed to be appreciative of the efforts, skills and enthusiasm of the others in the team. This is a happy and positive situation. (Participant 3)

Reflecting upon their own, and others' responses, participants commented they had gained an increased awareness of potential challenges enabling them to be better prepared.

> It helps me gauge how my colleagues view the interaction, and compare with my own views. It has helped me to be mindful of potential incompatibilities in perspectives, even just by reflection. (Participant 5)

Team responses regarding dealing with conflict indicated that the members thought the best approach was to talk about it and be open; a problem-solving approach. The team were not concerned or surprised about the potential for conflict and were confident they could resolve any issues with healthy debate.

Communication

Assumptions

The use of the narrative process exposed individual assumptions, enabling a better understanding of the perspectives and ideas being expressed by others in the team.

> I would have probably thought everybody's vision for teacher education was the same as mine, and not realised all the nuances that there are in its definition. (Participant 1)

> It made each of us reflect and hence consider the group dynamic, individual's concerns and feelings and perhaps how we need to modify behaviour/methods, or solidify that behaviour/methods and hence how to proceed to the benefit of the group. (Participant 3)

Interpretations

By the end of round 2, participants indicated overwhelming relief at being able to now properly understand what other team members had meant about something after reading their transcripts. One referred to the relief gained when they could see that some of the interpretations they had made of another's communication due to guesswork, could now be affirmed as being correct.

> Was interesting to observe the feelings of others in the group, rather than leave it to my guesswork. (Participant 3)

Shared language

> It surprised me that I think of our [other discipline] people as being both disciplines, yet when we started to organise this (event) there was a marked difference in responses between the (academics from the different disciplines) … there was a striking difference. (Participant 2)

The importance of having developed a greater familiarity with the terminology and the way it is used in each other's discipline, significantly increased the mutual understanding of shared experiences. One member revealed that having a shared experience, and learning the other discipline's way of referring to its aspects, meant that a discussion relating to the experience or a similar one enabled the listener to picture what the other was talking about more easily.

> If participants don't have shared experiences then negotiation can become ambiguous, so if I said something, others may not understand it. I found that at the other university I visited, when I was talking about teaching my course, they are thinking about it in terms of teaching their courses and it's not quite the same. So, having had two colleagues teach the course I also teach has helped, because when we talk we think about the same things. (Participant 4)

An unexpected but insightful revelation in the interview transcripts related to the interpretation of a very useful artefact belonging to the education discipline, the Quality Teaching Model (NSW Department of Education and Training, 2003). Opinions varied greatly as to how accessible, meaningful, and useful they found this model to be. Some described the language of the artefact as restrictive to outsiders, yet still expressed a strong desire to see the artefact in a more integrated way, so that it could be accessed for use by all disciplines.

> Initially we were quite careful about not using words like pedagogy. (Participant 7)

This quotation exemplifies how a mathematician, traditionally focused on CK, started engaging with educational constructs, thus learning about the intricacies and complexities of PCK (Goos, 2014). This learning resulted in a transformative experience for many participants:

> I use the language from the other discipline's model for quality teaching now. (Participant 4)

Data from the interviews also provided evidence of the confidence of those academics with experience in different disciplines in using the form of shared language they had developed. This confidence was a consequence of their experience in varied disciplines and evidence of the benefit of multidisciplinary experience to communication.

> The more time we spend together the more the language is becoming common. (Participant 7)

Building capacity

Some members described the narrative study as having enabled them to develop a greater capacity to listen and reflect more on both their own communication and the communication of others. The development of the capacity to apply the insights gained toward further improving their own communication and practice was also remarked upon.

> It's adding to my knowledge about our teaching students and how they learn mathematics – by talking to the people that are teaching them mathematics … I might have the students talk to me about what happens (in the other discipline) and it's easy to see them as two different things and yet for the students it's one thing. (Participant 7)

Also, the capacity to build individual member's careers through the learning made was emphasised by one of the participants:

> I will still be grateful for other aspects such as the generosity of the team, a potential publication, and the experience of a scholarly seriousness being applied to attempting a cultural transformation and the building of communities of practice. (Participant 2)

Ways of seeing

Shared vision

The greatest variation in opinions within the team was perhaps with respect to thoughts about shared vision. Roughly half of the team thought the shared vision was limited to the objectives written in the formal project outline, others felt it was something that continued to evolve as deeper understanding of the project and each other developed. Some thought its development required direct facilitation resulting in a one-off clear articulation, others thought it emerged naturally in purposeful interaction, such as that provided by this narrative inquiry process. Was the shared vision a combination of these? For despite the differences in opinion as to how a shared vision should develop, all but one was confident that the team had a shared vision.

> Having us each reflect on the vision and then seeing if they are really different … I think that is something quite rich potentially. (Participant 2)

> Visions are ever-evolving. (Participant 4)

Disciplinary paradigms and research approaches

The narratives provided team members with another way to discover disciplinary variations. Being able to learn more about these differences brought greater peace of mind for some and greater confidence to proceed. Several expressed a willingness to adapt their own words, actions and behaviours in response to this greater knowledge about how others saw things, where they saw opportunities to enhance working relationships, and the team's collaboration.

> I used to wonder 'what's going on over there' and they were probably doing the same. (Participant 6)

> I think this way of looking at things differently is perhaps very enriching to the research team. (Participant 1)

An example of the learning that can take place when elements of one practice are introduced to another arose in the area of conducting research. Differences in approaches relating to disciplinary background were revealed. It was seen that this could be an obstacle to multidisciplinary work, yet some saw the opportunity to learn about different approaches to research provided by this dissonance and concluded that the experience had enhanced their capacity to focus on a broader range of factors relating to research methods.

> The interdisciplinary interaction has encouraged me to take a more research attitude toward evaluating the teaching activities that I do. (Participant 3)

Having members of the disciplines share what they felt was important to solve the problems at hand, provided an opportunity for each to synthesise their own views with those of others in the search for solutions.

> It has opened my eyes to how academics (from different disciplines) can become a bit blinkered in a particular way of thinking and interacting. We have to explain ourselves more transparently I think. (Participant 6)

Many responses related specifically to epistemological differences between mathematics and mathematics teacher education. For example mathematicians in the team felt that teacher educators saw the project through a research lens, whereas their view was more pragmatic:

> We have different approaches… it's the informed practitioner on our side versus education research question on their side. (Participant 5)

Additionally, mathematicians in the team have a greater variety of stakeholders in their student cohort, and therefore necessarily view the knowledge of their discipline for teaching in a different way:

> [When we teach] we are thinking about BMaths students, but also engineers, physicists, scientists, nurses … everyone, teachers as well. But [mathematics teacher educators] focus all the time on teachers, which is a much smaller cohort. (Participant 2)

Participant 2, a mathematician, reflected on an event that both the mathematicians and teacher educators had organised, stating that "there was a striking difference between the people who identified as education people and the people who identified as mathematics people." Subsequently, when reflecting on a part of the event that consisted of a mathematics lecture, this participant stated that the worry that some teacher educators (the "education people" in the quotation above) had about the unsuitability of this lecture to attract an audience of teachers, was unfounded:

> She still put up a bunch of maths equations early in her talk … I think it didn't do any harm, because there were hardly any teachers there for it to harm and those that were there were probably the ones that were most confident with the mathematical language used.

Participant 7 saw the epistemological differences as a positive, stating:

> We come from such different backgrounds that I often notice something will come up and someone will have a different spin on that from their discipline's mind frame which is great […] The

> combination of our background is going to actually make the project better than it would be if any of us tried to do it independently.

The detail and the big picture

Interview responses indicated that some members of the team saw the larger goals of the project with slightly different emphases. There were also some disciplinary differences in how sub-projects were perceived and understood, with evidence that this improved over time and with greater involvement.

> The other person has a much broader way of looking at issues in Educational research. They look at the big picture always. That provides a completely different angle. It's like two different planets … a very different way of looking at things. It is very valuable. (Participant 1)

> I think it's the combination of our backgrounds that is going to actually make the project better than it would be if any of us tried to do it independently. (Participant 7)

The importance of team members being able to explore both their own and other team member's knowledge and understanding with respect to their vision and goals for the project was felt to be valuable and important by most of the team members.

Team members were also asked to respond to a question asking whether they think the other discipline sees things differently.

> I think that individuals vary more than disciplines. Inter-individual differences vary more than inter-disciplinary ones. (Participant 3)

Participant 4 put forward that multidisciplinary work "puts us more in constructive alignment" rather than more "insular and isolated" and hence unwilling to see the multiple perspectives and needs that "really" surround big picture issues. This team member drew attention to the importance of both disciplines having intimate knowledge of what the other is doing, enabling an integration for the benefit of teachers in training.

Creative risk-taking

Several responses implied team members' awareness that they were undertaking a form of creative risk-taking.

> It may not work as expected initially, but is it really a failure or has important learning taken place? (Participant 4)

> The fear that others who might be just reading my story (and not seeing the actual delivery) might misinterpret in some way what I said. (Participant 3)

An ability to notice things that he or she had not been able to notice before was a remark made by one member, who now noticed what mattered to others in a way he or she had not before. The participant felt this new insight was important to the collaboration and facilitated taking risks that could lead to new ideas for change.

> I think this way of looking at things differently is perhaps very enriching to the research team. (Participant 2)

Reflections on the narrative inquiry process

> I have found it an interesting mirror to hold up against us. (Participant 5)

The narrative inquiry process provided beneficial information at the level of the individual, team and institution, corroborating what was explicitly addressed by Waitoller and Kozleski (2013). Reflection upon the information given in their own and other team members' interview transcripts and written reflections provided team members with many insights. They stated that they could act upon some of these straight away to improve their collaborative working relationships within the project and further progress the project goals.

While comments regarding the narrative inquiry process were overwhelmingly positive, some remarks relating to concerns and suggestions for improvement also arose. For instance, concerns were raised about how emotionally charged the work could be, as well as concerns about methodological issues. One of the participants stated that there needed to be "a more well-defined set of research questions. This might make the process more 'compact'", while also raising the validity of the process itself:

> I don't believe we can take our transcripts at face value. I'm not saying any of us said anything untrue. It's just that I think only the eventual blended negotiated meaning will have a lasting value within our community of practice. (Participant 2)

In the last written reflection, comments emerged relating to the benefits of the narrative inquiry as a process for authentic learning. These authentic learning experiences provided new understandings that could be applied to their collaborative work in a multidisciplinary setting (Wenger, 1999). A comment by one of the participants summarises well the spirit and breadth of this learning:

> We became better able to work together from a common perspective due to a better mutual understanding of each other and our motivations, views of the project and different perspectives and paradigms. (Participant 1)

In particular, there were many comments to indicate that the narrative inquiry process aided team members' communication with each other, providing a better bridge across the gaps in understanding, background and simply knowing each other. The narrative process influenced their own communication constructions to achieve a greater effectiveness, as well as their confidence in interpreting and understanding what others were saying. Some examples of these reflections are:

> It informs us of differences in perspectives of the project. (Participant 5)

> [The narrative process] enabled insight into whether existing approaches i.e. behaviours and methods were productive for the group and hence if modification was required. (Participant 3)

The narrative inquiry process also broadened the perspectives of individual team members from the different disciplines, and participants were perhaps no longer on "different planets" (see quotation in previous section from Participant 1).

> [The narrative process we used, helped my understanding of] other people's views of the project, and understanding what different perspectives and paradigms can bring onto the research table. (Participant 1)

> [The narrative process we used] helps the team members look at the project from the other person's perspective. (Participant 4)

Conclusions

The aim of this project was to investigate how a team of mathematics educators interact and learn in the context of a multidisciplinary community of practice (Wenger 1999; Goos 2014) using a narrative inquiry process as a pedagogical tool for the team members to learn from each other across discipline boundaries. Our results exemplify, and perhaps confirm, what is manifest in existing literature with respect to factors that enhance, and those that have the potential to hinder, this type of collaboration. Mainly, the analysis of our narratives highlights the *importance of setting structures* to develop collaboration (Borrego et al. 2014; Carroll et al. 2014; Schaffer et al. 2008; Seethaler et al. 2013; Vanasupa et al. 2012; Waitoller and Kozleski 2013; Wenger 1999), that *dispositions of team members* may enhance or hinder cooperation (Carroll et al. 2014; Duffield et al. 2013; Ness and Riese 2015; Vanasupa et al. 2012; Waitoller and Kozleski 2013) and that *communication is integral* to achieving common goals (Carroll et al. 2014; Dillon 2008; Duffield et al. 2013; Vanasupa et al. 2012; Waitoller and Kozleski 2013; Wenger 1999). It is also often acknowledged that the different *ways of seeing* that emerge through multidisciplinary collaborations enhance the interactions and promote learning (Goos 2014; Vanasupa et al. 2012; Waitoller and Kozleski 2013; Wenger 1999) in ways that would not occur otherwise. Our analysis indicates that in the case of two fields as epistemologically distant as mathematics and education, these different *ways of seeing* can have detrimental consequences when they are not properly acknowledged, but can greatly enrich the collaboration when explored and engaged with by the participants. In particular, issues such as the avoidance of using certain language (e.g., the term pedagogy) or an individual's awareness of varying degrees of readiness to engage with epistemological differences need to be recognised in teams to enhance communication.

Perhaps the greatest success of this research is that it enabled the team members to be more mindful of learning about, and applying knowledge of, factors that may enhance and hinder their collaboration whilst they worked together. It also enabled the assessment of the narrative inquiry process itself for this type of learning. This study has helped shape strategies to improve pre-service education in our institution which could be used for improving mathematics teacher education globally. For example, as a consequence of this inquiry and the learning of the other discipline, teacher educators have started teaching CK within the discipline of mathematics education. Additionally, we have established a community of practice with preservice and practising teachers in our region that perhaps we could have not envisioned if it had not been for the conversations and subsequent reflections around our vision for preservice teacher education. Lastly, the modelling of a narrative inquiry method for authentic learning has enhanced communication and deepened relationships to support a sustainable collaboration.

This approach has the potential to enhance mathematics education communities of practice in contexts other than ours. We have changed the curriculum taught to pre-service teachers thanks to being able to understand disciplinary paradigms, and thus collaborate to improve the courses we teach (please see Prieto et al. (2015) for an example of these curriculum changes). Creative risk taking was instrumental in developing and delivering the outreach activities we have developed as part of this project by focusing on the detail and the big picture. Finally, as a consequence of our new shared language and increased trust in each other, we have been able to build our team's capacity by enabling the co-teaching of university subjects across disciplines in our community of practice. These strategies, which continue to evolve even after the completion of the project, would not have been possible without the interactions and learning that occurred

through the process explored in this paper and will be available to other teacher educators and mathematicians willing to undertake similar processes.

Our research exemplifies a process that interdisciplinary teams can use and adapt to enhance and sustain their collaboration. It also reveals some of the important needs and experiences of those working together in multidisciplinary teams. Awareness of these is important for collaborative work. Our findings suggest a process that enables a team to drive their own learning together in a way that catalyses deeper thought, discovery and communication, individually and collectively, improves relationships and the work of the team to achieve the project's goals. This process is not restricted to mathematics educators, and we believe it could be potentially used for any collaboration in a multidisciplinary team.

Ethical considerations

Participation on the study by team members was entirely their choice. The study was approved by the University of Newcastle Human Research Ethics Committee (H- 2015-0231).

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