Crossing new uncharted territory: shifts in academic identity as a result of modifying teaching practice in undergraduate mathematics

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The changes in academic identity a teacher may undergo, as they modify their teaching practice, will vary depending on their experiences and the support they receive. In this article, we describe the shifts in academic identity of two lecturers, a mathematician and a mathematics educator, as they both made changes to their teaching practice by implementing new questioning techniques in a large undergraduate mathematics course. Both lecturers were members of the research group, which became their community of practice. Our findings recommend that lecturers endeavouring to step out and try changes to their teaching practice, particularly with large groups of students, belong to a community of practice. The community of practice provides a place for shared reflection, new learning, and opportunities to negotiate new identities.

1.   Introduction

> While research usually involves engagement with an academic community, teaching has been characterised as an individual affair.   [1, p.242]

When lecturing is an individual affair, reflecting on teaching and making changes without support can be challenging. In mathematics, lectures are traditionally content-driven and students are passive listeners, who struggle to find their way among mountains of theorems, definitions and proofs, and to maintain attention throughout [2]. There is growing evidence of changes occurring in how mathematics lectures are presented, as research in this area at university level develops. Studies by Hannah, Stewart and Thomas [3] and Paterson, Thomas, and Taylor [4] are two examples which provide evidence that mathematicians benefit tremendously from involvement in reflecting on their teaching, and that partnerships are often very effective.

In this paper we use the metaphor of crossing uncharted territory, to provide a framework for describing the changes in academic identity a lecturer may undergo, while attempting to modify his/her teaching practice. Although other lecturers may have made this journey, individual experiences differ. As well, changes made without collegial support could be likened to crossing new territory without a map: *Which way do you go? Is it safe going alone? What are the risks?* The journey could seem so daunting that doing it alone may prevent many from trying and those that do travel without support may wither along the way. In this article we use the metaphor of a 'journey', although rather clichéd, to provide a mechanism for us to probe deeper into what might or might not be occurring with a lecturer when making changes, and thus framing the exploration.

We restrict our scope in this paper to understanding the changes in identity, which occurred for a mathematician and a mathematics educator, as they both made modifications to their practice while teaching a large undergraduate mathematics course. Both lecturers were members of the research group, which developed into their community of practice. We

do not investigate or evaluate the teaching intervention here, nor do we promote a particular way to form and use a community of practice. Instead, we emphasise the support the community of practice gave on the journey and why we believe this is crucial for successful change in practice.

The paper begins with a range of literature relevant to academic identity and communities of practice. A description of the participants involved in our study is next, with the methods used to collect and analyse the data. Our results follow, detailing the participants' shifts in identity as they journey into uncharted territory: the challenging terrain, the joy of the journey, and the spectacular views they came across. We end with a discussion on how these findings provide an illustration of the tensions a mathematics lecturer may experience making changes to their practice and how their identity may change as a result.

2.   Literature

This paper takes the theoretical view that academic identity can be constructed through involvement in a community of practice, through the role of reflection. We expand on each of these aspects in turn.

2.1   Academic identity

There are various definitions of academic identity in the literature as the concept is complex. According to Beauchamp and Thomas [5] and Clegg [6], early understandings were based on identity being static and stable whereas newer understandings describe identity as being flexible, dynamic, and open to change. Clegg expands this understanding by describing identity not as "as a fixed property, but as a part of the lived complexity of a person's project and their ways of being in those sites which are constituted as being part of the academic" (p.329).

From the literature there is a general consensus that an academic's identity will shift over time, as both individual and broader factors influence it. These factors may be internal, such as emotional or value commitments, or external, such as job and/or life experiences [5, 7]. How an academic constructs their identity will be shaped by the nature of their academic work. However, in most disciplines (of which mathematics seems to be such an example), Jawitz [1, p.242] claims that the nature of academic work is misleading as "teaching is viewed as a generic activity that lies 'on top of' the 'real' academic work, namely research". Lea and Stierer [8] also contend that "'research' is the trademark activity of the university academic, and the principal derivation of role definition, identity formation and intellectual fulfilment" (p. 608). And, according to Archer [9], teaching and other activities are at best only acknowledged in passing.

Skelton [7] believes that academic identities are inevitably shaped by both personal biographies and significant life experiences. The process is on-going, involving interpretation and re-interpretation of experiences as they are lived through. Academics, Skelton says, will develop personal theories of teaching and familiar pedagogical practices, which at the macro level will be influenced by the wider social context and structures, in particular how they understand, practice and evaluate their teaching. Furthermore, the literature adds that departmental and other significant communities of practice will impact on an academic's identity influencing how they are constituted [10, 11]. Skelton refers to Foucault's perspective on power and the impact this has arguing that "people are not repressed, dominated or coerced to behave in particular ways but incited to regulate themselves according to set standards, targets and/or 'appropriate' forms of conduct".

Gee [12] contends that although one might have a 'core' identity, this will differ depending on the particular context. He identifies four perspectives of identity which, Gee

insists, are not separate from each other but at various times and places different perspectives may predominate. Historically, the first perspective is called nature-identity (we are what we are because of our 'natures' or biologically how we are recognised); the second is institution-identity (we are what we are because of the positions we occupy in society); the third is discourse-identity (we are what we are because of our individual accomplishments as they are 'interactionally' recognised by others); and the last is affinity-identity (we are what we are because of experiences we have had within certain sorts of 'affinity groups'). Gee argues that this fourth perspective is gaining popularity with researchers as a way to view identity, as people are encouraged to share through participation in groups.

2.2   *Identity construction through involvement in a community of practice*

One example of an affinity group, which Gee [12] refers to, is a community of practice (CoP); a place of collaborative inquiry where various approaches to teaching can be tested through a reflective sharing process [13]. As participants share knowledge, ideas, and approaches, new ways to develop and improve teaching can be learnt, while challenging existing pedagogies. The traditional idea of thinking as an individualized process challenges our understanding about learning within a CoP. Working within a group can contribute to deeper levels of awareness and achieve new learning that can, in turn, lead to significant change. In a CoP, members decide what to identify with and how to promote it, facilitating the negotiation of new identities [13].

These understandings are based on the work of Lave and Wenger [14] who state that CoPs are places where learning is a socially situated activity, and a combined process dependent on previous learning, along with the present learning context. As individuals interact within a CoP, Wenger [15] argues that they attempt to make meaning out of what they are doing through interaction (the process) and reification (the product). The interaction is done through engaging mutually with others or doing things together, understanding and fine-tuning the tasks at hand, and, developing a shared repertoire of resources, discourses, and styles for working on the tasks. The reifications are the products of doing things, and input to more participation, which is important for continued productivity [16].

Wenger [15] believes that the connection between practice and identity is significant, describing them as "mirror images of each other" (p. 149). Both, he argues have the same five characteristics: identity is the negotiated experience of self; involves community membership; has a learning trajectory; combines different forms of membership within an identity; and presumes involvement in local and global contexts. For new academics joining a CoP, it might be expected that they will particularly feel the impact of working within a new context and will need to be aware of how their own identities are shaped within this context [5]. Van Zoest and Bohl [16] clarify that "when learning happens in a community, it takes place because of an imbalance between a person's experience and the community's regime of competence" (p. 322).

Within the mathematics education context, working within a CoP assumes academics will work together to understand how to best teach mathematics. However, many academics will participate only peripherally and continue to teach in the way they have been taught and with the books they are given or choose to use. The strength of the effect of textbooks, and the curriculum, can be so powerful, that they determine what gets taught in the mathematics classroom, and can define for academics what the teaching of mathematics is [16]. Thus, there is a tension between the CoP being a problem or a possibility. The problem is the enormity of redefining one's practice in relation to new regimes of competence and accountability, as it may be viewed as too large a shift away from well-developed beliefs about teaching mathematics, or as too much trouble given the comfort in the current practice. In contrast, possibility suggests opportunities to become reinvigorated and to reinvent

themselves as active participants in the endeavour to better understand how to teach mathematics well [16].

2.3   The role of reflection

Reflection has its roots in philosophy, and particularly the work of Dewey [17] on reflective practice for personal and intellectual growth. Many early researchers have influenced the area of reflection, including Friere [18], Habermas [19], Schön [20] and Giroux [21], suggesting that a professional can improve their practice through reflection. Reflection can be variously defined from different perspectives and disciplines but at the broad level, Ryan [22] presents a useful definition saying:

> … it includes two key elements (1) making sense of experience in relation to self, others and contextual conditions; and importantly, (2) reimagining and/or planning future experience for personal and social benefit. (p.2)

The role of reflection in academic development is now well recognised in the literature as an important means by which academics can become more in tune with their sense of self and a deeper understanding of their teaching [5, 22, 23]. In this way, reflection is central to the developmental process as it presents questions such as: What do I know about teaching and learning? Who am I as an academic? This approach requires looking back at thoughts or practices and considering the effectiveness of them, then establishing a goal or vision for a future identity. Through collegial interactions within a CoP, Lieberman concludes that academics have further opportunities to reflect and re-develop their skills, knowledge, and beliefs about teaching and learning that directly influence their practice.

According to Herbers et al. [13], the ultimate purpose of the CoP is to improve practice. They hold that through shared experiences related to teaching, with a reflective perspective, new ways to improve actual practice can be devised. Introducing specific teaching-learning strategies, and experimenting with a variety of means to involve and engage learners, the results can then be brought back into the CoP for reflective discussion. In this way, the members of the CoP dialogue about the learning engagement and evaluation of the new approaches, developing and testing them, leading to improved practice. Usually tertiary academics are appointed on the basis of their knowledge, qualifications and experience in their subject area with no formal teaching qualification [24]. Thus, the advantage for tertiary academics working collaboratively within a CoP is an opportunity to reflect on their practice through social engagement. Viskovic also recommends that more CoPs be nurtured because of the potential to progress academic development in this way.

3.   Method

3.1   Participants and setting

Five researchers (a mathematician, three mathematics educators, and an academic developer with a mathematics education background) from a large university in New Zealand formed a CoP to investigate the effect of lecturer-posed questions in large undergraduate mathematics lectures. All five members had experience in teaching mathematics courses at the university level. They worked together over a period of three years to design and test techniques for implementing questions in a first year calculus and linear algebra course, with the goal of increasing student interaction and understanding within lectures. We focus on two participants in the CoP, Chris and Jane (not their real names), who volunteered to make the journey. Chris is a pure mathematician who implemented the questioning techniques from 2009 to 2011. Jane is a mathematics educator and was part of the team in 2009 and 2010

before moving to another university abroad, consequently leaving the project. These descriptions of themselves are based on their postgraduate qualifications and their current research foci.

The course Chris and Jane taught caters predominantly for first year students not majoring in mathematics, and has an ethos of delivering a skill set to students who will use mathematics in other areas of academic fields: predominantly business and economics, statistics, computer science and the physical sciences. Approximately 800 students enrol in the course each semester (fewer in the summer semesters), and lectures are delivered in multiple streams consisting of 100-350 students. During regular semesters, a team of up to eight lecturers deliver the same content. Each lecturer follows a common lecture schedule, and teaches from a pre-published series of lecture slides that most students purchase. The lecturing team consider it important to teach in this consistent manner, in order to prepare the cohort equally for common assignments, tutorials and tests.

3.2 Data collection

Both Chris and Jane kept journals on their teaching, reflecting on the process as they implemented the questioning techniques. Chris was interviewed four times either during the semester in which he taught the course, or immediately after the course finished. Jane was interviewed twice. Semi-structured interviews were conducted within the CoP, requiring Chris and Jane to reflect on the effectiveness of the questions and questioning techniques they implemented as well as their teaching goals and beliefs. They also reflected on how their teaching identities changed or were challenged by having to implement this new kind of questioning technique. This approach allowed us to probe their perceptions more closely if needed. All interviews were audio-taped and transcribed.

3.3 Data analysis

The interview transcripts and the written reflections were coded and analysed through an iterative process [25]. The authors first coded independently to identify recurrent themes and stories that emerged from the data then compared and revised these until consensus was reached. Chris participated fully in the data analysis. His dual role introduces potential for bias in the results, as he may have been inclined to show himself in a positive light. This was mitigated by the involvement of the rest of the CoP, who could dispassionately challenge Chris on his perspective, and by alternating between independent coding and team consensus to check and corroborate findings. The CoP felt that it was an advantage having Chris involved in the analysis, as he was able to clarify aspects where the transcripts were unclear or ambiguous.

4. Results

In this account we examine the journey that Chris and Jane travelled, as they introduce some changes to their teaching in a large undergraduate mathematics lecture. We use headings related to the metaphor of crossing unchartered territory to signpost their journey and provide a framework for the exploration.

4.1 Identity at onset

At the beginning of the project, Chris' mathematician identity was most prominent, in that he focused on the mathematical content. Being used to a traditional lecture style, Chris said "I think I gave good lectures, but for the most part they were 'sage on the stage' style", and

I felt the pressure to deliver the 'expected' product … a pressure to deliver everything in the course material … a pressure to deliver the same experience that other streams get

Chris recognised that traditional lectures were not always effective, saying "You don't learn it by watching me do it."

In comparison, Jane's identity as a mathematics educator was well-established. She was recognised within her department as a senior lecturer, and an established researcher in the field. Jane was cautious about trying things out in her lectures and was often frustrated with her performance. Within the CoP, she was very open:

In my mind there's this tension… you've got this massive lecture theatre in which you only have a vague sense of how as a group they're all following the maths but I don't know that I always make the right call.

4.2 Challenging terrain

On their journey, both Chris and Jane found the 'tyranny of content' in the course challenging and talked about pressure from the students as well as the department to provide as much procedural detail as possible without a focus on the students understanding of the concepts. Jane declared she would "put a lot less in the lectures if I had complete control over what was to be in the course". Chris wanted time to delve deeper into the mathematics, and was frustrated that as "there are some lectures where there's not a lot of time to get through all those slides".

Jane struggled to let go of procedural and introduce conceptual material:

I was always conscious of how do I handle this and to what extent you know at some point I need to move on and so that was always a tension for me.

Jane did not find introducing a conceptual question as easy as she thought it would be which caused anxiety for her that her mathematics might not be up to the level needed:

I end up feeling horribly under-prepared and oh this is all going pear shaped because I don't quite know what I want to say here and it's really not clear.

There were unexpected challenges too. Both Jane and Chris expressed they had not anticipated the difficulty in getting students to engage. Chris said "it felt like they were thinking… if I sit here quietly you'll tell me the answer" and was concerned about being a bully if he pushed for discussion:

I didn't want to be the bully… I think I, how do you put it, politely bully. I directly tell the students to work in a team.

There were times when he was frustrated with students saying "how much hand holding can the students need?"

Jane discovered that making changes meant giving away the script, which was risky and challenging for her as she could never be sure what questions might arise. She says:

When you have a class of 200 it's actually just so much harder to deviate from the script and be responsive to what's coming from the class.

Buoyed by the support from the CoP, Jane traversed the terrain more easily, and continued to test out this new initiative. She found, however, the little decisions she used to make had now become big decisions:

> You have to make all sorts of decisions about how long you want to spend on this example, how much the rest of the class is with you, how much time are you going to invest in getting the whole class together again and its actually making those decisions in a more successful way which is the key.

Although the CoP worked together to come up with the design of possible questions, both Jane and Chris recognised the importance of each implementing the questions in their own style. Chris explained that "the hard part you can't really plan for is after the question, getting the feedback and not knowing what the students are going to say." Both elaborated on this issue to explain that it is the way they respond to the questions which is important; the need to confirm the correct answer and value student responses. Chris explained:

> It's very natural to say okay who knows what the answer was, elicit that response from the class, get an answer you know, validate it, rephrase it in your words so you're happy with the answer that everybody copies down and then go on with the lecture.

Chris' identity as a mathematician was always at the fore, and he explained how he continually felt the need to paraphrase a student answer to make it "mathematically correct while trying to preserve as much of the student's dignity as possible". Similarly in the same vein, Jane described an instance where a student gave an unexpected answer that was not correct and she moved on to other student responses to get the 'right' answer. Chris admitted that "I'm still falling into the trap of confirming their answer", which he was working to avoid as otherwise the students would just wait for his answer, rather than justify their own.

The biggest fear for Jane was what questions might arise from the students: "Everything you say opens another can of worms because it is a bit more spontaneous." Jane was also anxious about how long to let the students discuss, and worried about having to stop them discussing. Chris was keen to have a lot less content in lectures and more time for discussion in the class:

> There is a pressure to deliver the same experience that other streams get; skipping lecture slides to spend more time on something else diverges from the status quo.

He commented on the pressure he felt to remain the content expert:

> I would be uncomfortable with leaving something hanging. If it was a statement that was put to the class that wasn't refuted by the content expert in the room, you're implicitly approving of it, so I would feel uncomfortable leaving a half formed answer like that.

4.3   Enjoying the journey

Chris was keen for his students to understand the mathematics and benefit from their time in the lecture in a new way. He told his class "we want you thinking and talking in class". He welcomed being in a CoP and the support it offered him on his journey:

> Being involved in research on questions in lectures has given me the confidence to do more of what I see the need for in lectures, because I know what I'm talking about when it comes to some of this stuff.

Jane also identified the CoP as a prime factor in making her journey more positive:

> Preparing and teaching lectures this semester … felt qualitatively different due to a number of factors. I am certain that being in a CoP - and the regular reflection and discussion of teaching practice - is one of them.

Both Jane and Chris found the process of reflecting within the CoP rewarding. Their confidence grew as they observed the students engaging more in the mathematics questions, with Jane saying:

> It really felt like there was a mood in the class where people were engaged ... and I managed to handle the discussion in a way that got them thinking more deeply. I think I was not afraid of not having neat answers to all the questions, and to have to think on my feet.

4.4   Spectacular views

As Chris and Jane continued their journey, there were times when they saw spectacular views – new insights they developed about their own identities and how they play out in their teaching. One instance for Chris was realising his goal for teaching had moved beyond getting students to work on problems in class to discussing the mathematics:

> I was kind of torn because when you gave them a question they were quiet, clearly they were working… but I wanted them to be *talking* about the maths as much as working on the maths.

To Jane's surprise, she realised that the effectiveness of the initiative was not about her or the answer she could provide, but about how effective the question was at engaging the students:

> My attention shifted from the material I was teaching, to student learning. I was much more likely to follow my own instincts about what was worthwhile – even if it meant missing out half a lecture to make room for something else.

As Jane witnessed the students playing with the maths questions she realised that there was less emphasis on her having to know everything. Her fear of being exposed was unfounded: "The moral for me is that I don't need to know everything or even to say everything that I know". The spectacular view Jane saw was when she found she was able to keep the class together by letting them engage with the question rather than trying to provide perfect answers:

> It was *not* trying to give a good answer to the question that kept the class together here ... they could all engage with the question... but they would not all have engaged with a garbled attempt at a proper answer.

As Chris provided more questions and had the class discussing these, he became convinced that it was pointless doing lots of examples:

> They've just seen two like it and you're asking them to do another one. If they already knew what to do from the first two, it doesn't teach them anything.

Jane agreed that too many examples were not productive and was pleased when a question engaged the students in mathematical discussion. She also realised it was more important to

engage with a question than focus on the answer, and increasingly took more risks with this new approach.

4.5   *Identity shift*

Jane now resists the need to supply all the detail and lets some of the content go unsaid. Instead, she concentrates on the bigger picture of what she considers important for the students to understand:

> I resisted letting the mathematician get the upper hand, and deliberately didn't dot all the 'i's and cross all the 't's. … It is about the willingness to let things go unsaid, which I am trying to develop in myself.

Jane is also prepared to put more of her theoretical knowledge about mathematics education into practice:

> I would prefer students to have a good understanding of basic principles (from which they might go on to mull things over for themselves), than a half-remembered, half-understood collection of more detailed ideas. … I would now take some of the time that you use on examples to develop conceptual stuff or to do one example in a very conceptual way.

For Chris, his identity as a mathematics educator was emerging. He described the interplay between the two roles he played, of either lecturing behind the podium, or wandering around the lecture theatre as the students discussed a mathematics question in small groups. Similar to Jane, Chris grew in confidence about what content was important for the students and letting go the expectation of presenting it all in the given time. He was also more determined about using a question to push the students' understanding and have them actively involved in their learning than simply providing examples:

> There are some lectures where there's not a lot of time to get through all those slides and I just didn't worry about it … and it's the confidence in saying I think my question is more useful than that example.

5.   Discussion and Conclusions

Returning to our metaphor of crossing uncharted territory, Chris began as a novice; he had very little experience in mathematics education research with no previous experience of exploring new terrain. In his teaching journey he had always relied on his intuition and had been reasonably successful in this approach. Jane, however, had plenty of experience with considerable mathematics education skills, but lacked confidence to attempt crossing new land that was uncharted, stepping out of her comfort zone. Nevertheless, as Jane began to explore and try changes, her confidence grew and she began to trust her own knowledge of the content.

Our metaphor can provoke many questions but we consider three in particular: *Which way do you go? Is it safe going alone? What are the risks?* With respect to making changes in teaching undergraduate mathematics, these questions could be translated as: How did Chris and Jane know what changes would work in the lecture? What would happen if they made changes on their own with no support? What were the risks involved making these changes? On a journey, it is easy for trekkers to take risks heading off into uncharted territory alone. It is possible to navigate without a map or compass, or even guidance from others, and assume there will be enough landmarks along the way. Yet, the risk of being intrepid in this way is to end up travelling unsuitable paths. In a mathematics lecture making a change from being predominantly skills-based to involving students talking mathematics to each other and being

engaged in the material can be a considerable risk and result in disaster. Students' expectations are generally to maintain a passive role to allow the lecturer to get through the content in the allotted time [26]. Requiring them to be involved in discussion, breaking away from the mathematical norm, has huge implications for the lecturer's mathematical content knowledge and pedagogical knowledge. Without support, the lecture risks being a failure with negative knock-on effects for the lecturer and the students.

Being alone in the wilderness can be daunting and returning back to safety seems preferable to persevering; making changes in the mathematics lecture without support can be a gamble and safer to return to content-driven lectures with passive listeners. Being determined to succeed in the wilderness without adequate provision is dangerous; allowing students to engage in discussion and ask mathematical questions can be terrifying if a lecturer is concerned about his/her level of mathematical knowledge or ability to control class discussions.

In the case of Chris and Jane, attempting to change their practice on their own and without support could have been too difficult or overwhelming. If they continued, the class may not have understood what was happening and could have lost confidence in both their lecturer and themselves. Furthermore, going alone means no one to discuss difficult decisions with, about how to deal with challenges, and there is no collective sharing of resources. Starting off keen and eager, with no backup when the trek gets tough can result in energy levels fading as well as morale.

The research group that formed the community of practice for Chris and Jane provided their support. With the assistance of the group they were able to reflect on their journey as they travelled, and discuss the changes that were occurring in their identities. Chris knew the type of territory he was to cross and what it involved but had no experience of how to navigate it; he knew the content well, was a strong mathematician but lacked pedagogical knowledge. Conversely, Jane had many of these skills compared to Chris, but doubted her ability to cross this uncharted territory; she was anxious about what mathematics questions could be thrown at her and exposing her weaknesses. As they travelled, they expressed their fears with the group and together explored possibilities for success. Both came to recognise their strengths and gained confidence to travel further; Chris became more confident as a mathematics educator and Jane as a mathematician.

How then did the community of practice help Chris and Jane successfully make their journey across the uncharted territory? As they began their journey each member in the community provided knowledge of what they thought the uncharted territory might look like and what to expect. They were able to make suggestions, help with the reflective process, provide external encouragement or support, observe in the lecture theatre, pool resources, ideas and experience. Over time and with repetition the confidence Chris and Jane originally lacked began to grow, and they became more experienced, providing evidence that they were moving from the periphery of the community of practice to a new position of participation as described by Lave and Wenger [14]. The collegial interactions which occurred amongst the group members provided a reflective perspective which Herbers, Antelo, Ettling and Buck [13] argue is important for supporting and improving practice.

Although our findings recommend that mathematics lecturers embarking on similar journeys, endeavour to step out and try changes to their teaching practice, our emphasis is on the support within the discipline to provide a place for shared reflection, new learning, and opportunities to negotiate new identities. This support was crucial for effective and long-lasting change. Belonging to community of practice that has a mixture of mathematicians and mathematics educators "enables cross-fertilisation of ideas", which according to Paterson, Thomas, and Taylor [4] is important for mathematics lecturers professional development. However, the formation of a 'community of practice' and how it is maintained is an area for

further research. Although the members of the group were like-minded and met frequently over the three years, it could be argued that there are not enough dimensions to fully support the concept of what a true community of practice entails consistent with the work of Wenger [15] and other researchers [5, 13, 16, 27].

Finally, although this study follows the journey of two mathematics lecturers, it has implications for lecturers in other disciplines who may be willing to make changes in their teaching practice but concerned about doing it alone.

Acknowledgements

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