Factors influencing mathematics and science teachers’ self-assessment as teaching ‘out-of-field’ in rural and regional schools

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Abstract
Teaching ‘out-of-field’ occurs when teachers teach a subject for which they have no disciplinary or methods qualification. The incidence of out-of-field mathematics, science and technology teaching are particularly high in rural and regional areas. Given that mathematics and science are key areas of policy concern, there is an urgent need to understand teachers’ position in this increasingly common practice in order to provide appropriate system responses. This paper asks the question, how are mathematics and science teachers’ professional identities influenced by having to teach out-of-field? Twenty teachers who had taught science or mathematics at some time in their career, two school leaders, and two support staff, took part in semi-structured interviews, which I then transcribed. This paper reports on a thematic analysis of a subset of the data that isolated factors influencing teachers’ self-assessment of themselves as out-of-field or in-field. Excerpts from the interviews are used to introduce and contextualise these factors within rural and regional settings. These factors are used to generate a theoretical model, the Boundary Between Fields (BBF) Model, that enables analysis of the impact of these factors on identity construction during a boundary crossing event. The Model highlights the influence of support mechanisms, contextual factors and personal resources on the nature of teachers’ negotiation of subject boundaries and its impact on professional identity. This innovative model provides a platform for re-conceptualising these experiences as opportunities for professional learning occurring within schools as communities of practice, where teachers are supported and enabled to expand their professional identity. These findings provide insight for policy-makers, school leaders and teacher educators, into the complexity of the issue for teachers, as well as the conditions required for such teaching to be considered learning opportunities.

Key Words: Teacher identity, Teaching out-of-field, Science and Mathematics teacher, Teacher allotment, Teacher professional learning, Rurality

Introduction
This paper explores the professional identities of teachers who have taught subjects out-of-field, teachers who have taught maths or science out-of-field, or maths- or science-specialists who have taught other subjects out-of-field. While quality education requires an adequate supply of teachers, shortages of qualified teachers, particularly in rural and regional Australia, have led to an increase in the incidence of teachers having to teach subjects for which they do not have tertiary disciplinary or methods training (Department of Education Employment and Workplace Relations, 2008; Department of Education Science and Training, 2003; Education & Training Committee, 2006; Harris & Jensz, 2006; Harris, Jensz, & Baldwin, 2005; Lyons, Cooksey, Panizzon, Parnell, & Pegg, 2006). Recent international and Australian studies have drawn attention to this practice by highlighting its effects on teachers, learners, colleagues, parents, governing bodies and school management (see, for example, Steyn & du Plessis, 2007; Ingersoll, 1998, 2002), although generally the impact on teachers is both under research and under theorised. Data emerging from research into teacher supply and demand demonstrate how poor attraction
and retention of teachers increases the extent and longevity of teaching out-of-field. For example, a report by the Victorian Department of Education and Early Childhood Development (2008) shows an increasing trend in the percentage of Government schools reporting difficulties in filling teacher vacancies, particularly in some rural or regional areas, and particularly in the learning areas of mathematics, science and technology. Teaching out-of-field is inevitable under such circumstances (Australian Education Union, 2009; Lyons, et al., 2006). In fact, Lyons et al. reported data that science, ICT and mathematics were two times more likely, and in remote towns three times more likely, to be taught by unqualified teachers than in metropolitan schools.

A pilot study called *Teacher Identity In and Across Subjects* examined the influence of teaching out-of-field on teacher professional identity and the support mechanisms and coping strategies that teachers used. The innovation of this pilot study lies in the theorization of teaching out-of-field as a ‘boundary crossing event’. Star (1989) used the term ‘boundary crossing’ to represent the process of extending and negotiating working boundaries beyond the in-field space to an out-of-field space. In the context of this study, teachers can be seen to utilise ‘boundary objects’, as professional learning opportunities to support this negotiation. I argue that such boundary crossings, if negotiated successfully, can provide opportunities for identity expansion and a re-conceptualisation of practice.

Central to the analysis presented in this paper is the effect of teaching out-of-field on teachers' professional identities (Connelly & Clandinin, 1999). A teacher's work and identity, or ‘sense of self’ (Helms, 1998), is organically bound up in their knowledge and appreciation of the subject (van Manen, 1990). Research has shown that subject departments act as the locus around which secondary teachers gather, collaborate, develop identities, and support each other (Siskin, 1994; Stodolsky & Grossman, 1995; Tytler et al., 2009). A socio-cultural framing of identity describes it not as fixed, but as an ongoing process of becoming (Beijaard, Meijer, & Verloop, 2004) where context plays a crucial role (Beijaard, et al., 2004; Connelly & Clandinin, 1999). The modern self, according to Giddens (1991), ‘is not something that is given…but something that has to be routinely created and sustained in the reflexive activities of the individual’ (p. 52). From this perspective, the development of a subject teacher is a continuous process of identity construction that takes place as the teacher interacts with and reflects on their professional and personal experiences. Teachers’ socio-historical interactions with their subject equip them with competence and confidence in their teaching, in this case, school mathematics and science. While current theory is quite extensive in the area of teacher identity, there is a need for research that focuses specifically on identity in relation to the increasingly important issue of teaching out-of-field.

**Research methods**

The project generated rich qualitative data at a local level through school-based field research at three Victorian rural or regional secondary schools (School A, School B, and School C).

Strategic sampling (Neumann, 2003) was used to select schools. School A and B were rural schools offering Prep-Year 12. At the time of the research, School A had an enrolment of 142 students, School B had 220 students. School A was in a predominantly wheat growing area and serviced mainly a farming community. School B had students from both town and farming communities. School C was in a major regional town, offered Years 7-12 only and had an enrolment of 732 students. At the time of the research, the school was undergoing an amalgamation of two campuses into a single site.
At each of the schools, the principal was asked to nominate teachers who had taught science or mathematics at some point in their career. In total 23 teachers, and leadership and support staff, participated in the research.

The teacher interview questions were based on the following:

- background and qualifications for their in-field- and out-of-field subjects;
- perceived differences in the teaching in in-field and out-of-field subjects;
- teachers’ coping strategies;
- preparation through pre-service teacher education;
- pattern of professional development uptake;
- differences in the way the teacher operated in the departments of both subject areas; and
- the place that each subject has in the teacher’s construction of a professional identity, and how this might be seen to influence their teaching.

The interviews were digitally recorded and transcribed. A thematic analysis (van Manen, 1990) of the interview data was used to identify the major issues surrounding teaching out-of-field. This paper reports on data relating to whether teachers’ self-assessment of being in-field or out-of-field aligned with their qualifications; and factors leading to this self-assessment.

Results and Discussion

Whether a teacher identified with the label of out-of-field depended on a number of factors. Three groups of factors emerged from the data as impacting on out-of-field teachers: Contextual Factors, Support Mechanisms, and Personal Resources. I developed a model called the Boundary Between Fields (BBF) Model to examine the relationships between three groups of factors. The three groups of factors are shown in Figure 1 and explored below.
1. Contextual Factors

Contextual factors related to issues specific to the geographical region, school size and design, socio-economic status, and school and state governance structures, practices and policies.

In these rural and regional areas, rurality influenced availability of resources, collegial support, and professional learning opportunities for these teachers:

(32) I think the challenges are probably created because over a period of time you become settled in the areas for which you are qualified and feel comfortable. Then suddenly, you find years later, perhaps you are moving into another area, it is a challenge. But I think that's what teaching is all about, a challenge, and certainly if you're working in a bush school like School B I think you've got to be fairly adaptable and where possible try and accommodate, the needs of the school, more so the needs of the students, and I feel happy with that. [B4:50]

According to B4, in this rural setting, teaching load becomes a product of the mix of teacher expertise, student needs. The rural context created a range of limitations and possibilities for the out of field teacher. While rural settings provide many benefits for schools, such as varied teaching opportunities and community participation (Tytler et al., 2011), rurality limits the supports mechanisms available for the out of field teachers because of limited immediately available subject specialists to ask for advice, and the
tendency for professional development to be held at a great distance from the school. Certainly, attraction and retention of qualified teachers in rural areas provides a constant pressure on schools.

Governance practices determining the circumstance under which the allotment is given had some bearing on whether teachers felt out of field. Circumstances related to the decisions that led to leadership placing teachers out-of-field. For the teacher, this translated into the degree of choice, or autonomy, in their teaching. For leadership, decisions were made out of a need to fill the gaps in the timetable. Teachers were sometimes asked by leadership if they were interested in or felt confident teaching a subject, so, in some circumstances, teachers had some input into their allocation. Science teachers were often targeted for maths. A6, who was responsible for the school table, recognised the dilemma facing school leadership. A7 and B3 explain different circumstances under which they have taught out-of-field.

(31) There’s two types [of teachers]...You’ve got a group that may not be qualified, but have got an interest and understanding, even though it’s not on paper. And I think that’s probably better, if they’re interested and know their stuff; but also some teachers have to be just put in an area, like for example, like I had to put A2 into science, not that she wanted to. But she was our design tech person, and if we wanted to accept her husband here who is also design tech, there’s not enough design tech for two of them. So I said someone’s got to be prepared to teach outside their area and she said ‘Oh yes, I will, I will’. So she’s prepared to, but, although she didn’t have the knowledge to start with they need to be prepared to get to know their stuff. But also have good control, good teaching skills. [A6:121]

(29) Sometimes it would mean that that person who would normally teach that subject is away, like on leave or something like that, like for an extended period of time so you might be on your own and perhaps having to rely on friends or other people in other schools or people here who might have taught the subject before for any support that you might need. [A7:56]

(30) History is out of field, but it was an interest area... When I first came here I had two maths classes, and then the science teacher left, so I took more science, and I’ve only – in the last three years – started to teach maths again. And I asked to do that; because if I wanted to get a transfer I thought that having a bit of maths behind you would help. [B3:32,38]

The data presented here shows that teachers found themselves teaching out of field for a number of reasons:

(a) ‘covering’ someone else’s load on a short or medium term;
(b) filling in on a longer term to cover a longer absence;
(c) load allocation, where there are no other teachers available; and
(d) by request to do something that was of interest or for other advantages.

2. Support Mechanisms

The availability of support from teachers within the school, and from networks outside of the school influenced teachers who wanted to improve their practice. The quote from A7 above, for example, demonstrated the need for teachers to be resourceful and develop or tap into a support network. In addition, C2 had been part of a successful teaching team facilitated by a Teaching and Learning Coach who worked with the teachers to develop a differentiated maths program designed for a new open space classroom. This exemplar demonstrates the effect of support mechanisms:
I don’t feel out-of-field anymore because I’ve been incredibly supported by the teachers who are in-field. [They’ve given me]: previous work from students; expectations of what we need to actually get done in certain timelines in terms of, okay, there are three weeks of these activities, two weeks of these activities, and facilitating that... Access to resources: online resources, previous experiments that have worked, that haven’t worked, innovative ideas that people have used. It’s just been, a whole bag of experiences from other people inputting their experiences to a graduate teacher. And someone out-of-field. [C2:66,70]

Support Mechanisms can be referred to as ‘boundary objects’ that act as bridges between in-field and out-of-field spaces. Star (1989) describes boundary objects as ‘bridges’ or ‘anchors’ between ‘intersecting social worlds’. Such objects are considered ‘plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites’ (Star, 1989). In relation to his work on communities of practice, Wenger describes boundary objects as ‘forms of reification around which communities of practice can organize their interconnections’ (Wenger, 1998, p. 105). Objects can be human or non-human, and come in the form of artefacts (tools), discourses (as a common language), or processes that allow coordination of actions. Boundary objects are central to the teacher professional learning of out-of-field teachers because they improve the likelihood of a successful boundary crossing. While tertiary qualifications are used to determine a secondary teacher’s ‘field’, other factors, such as career trajectory (Siskin, 1994) and professional learning (see, for example, Little, 1999), have been found to be cogent in determining how teachers approach teaching and learning. Professional learning is the growth of teacher expertise that results from a wide range of professional development activities.

3. Personal Resources

Personal Resources refer to teachers’ knowledge, their dispositions towards the subject and teaching the subject, and how adaptable they are in their out-of-field role.

Teachers referred to the lack of the required teacher knowledge of content and pedagogy as one of the main factors influencing their self-perception. Of most concern for teachers was a lack of content knowledge. The breadth and depth of this content knowledge related to their background in the subject, whether they had knowledge of stories or practical applications, whether curriculum documents were made available, and was also associated with their knowledge of the students’ learning needs.

For example, knowledge and accessibility of curriculum documents was mentioned by a number of teachers. One teacher felt out of field teaching maths in the secondary area, having been a generalist primary teacher who had acted as a primary maths specialist. A difficulty he faced was the difference in the culture of maths teaching, in particular the introduction of the textbook posed hurdles that he had to overcome. This experience is contrasted below with that of A2 who felt comfortable partly because of the safety net the textbook provided.

The textbook was a bit daunting at first, because that becomes your bible; it becomes a lot more prescriptive. Whereas primary – yeah you’ve got an overall view of what you’re going to put in to the year, but you can vary it a little bit if something pops up [A5:116]

Well the textbook’s telling you what you have to teach specifically. So it’s easy to follow the VELS. [A2:29]
Having a curriculum document or syllabus that guides what needs to be taught, and teaching strategies and activities, made C2 feel less out-of-field (previous section).

Knowledge of learners was raised in relation to whether teachers had adequate pedagogical knowledge and skills, and was considered by some to be more significant for less experienced teachers, or was raised in relation to differences between primary and secondary students.

(25) The content wasn’t a worry because my initial studies was mathematics, and we did mathematics up to Year 12. It was probably just how you deal with the kids, so they’re 13, 14 year olds, they’re not 8 and 9 year olds, so strategies that work with an 8 and 9 don’t work with a 13 year old. [A5:116]

Interesting was that some teachers felt out of field because they lacked knowledge of how to engage the students, while other teachers felt in-field because they were happy to perpetuate traditional approaches. C1 in particular raised the importance of appreciating the link between concept and activity.

(5) The resources, there’s a plentiful amount of resources these days on the Internet and things like that. But to be able to use them effectively, I think that you really have to be in touch with the subject that you’re teaching. So, there’s no point in going on the Internet and getting some interactive activity, because you can’t connect that to what you’re actually doing in the classroom. And kids pick up on that really quickly I think. That was my problem with Maths. [C1:80]

Being able to relate to the subject was important to a number of teachers. A2 drew on her nursing and agriculture background to provide applications for science ideas in relevant topics, such as genetics, chemistry, soils, weather, and biology; however she struggled in some other areas

(14) … I do tell stories there too about selecting Bulls to use over particular cows for features and things like that. And the weather and soil biology and all that sort of thing. Um, yeah, probably the most uncomfortable I felt was with the Physics, which, I suppose my husband would have been a lot more comfortable teaching with the gear ratios and that sort of thing…which I didn’t really have anything to do with on the farm….Yeah, so I personally couldn’t relate to it. [A2:88-92]

Confidence and commitment were two dispositions that were associated with the other factors.

Having confidence with disciplinary ideas and modes of inquiry appeared to determine the degree to which teachers felt out-of-field and was mentioned by many teachers. Confidence was seen to be gained through tertiary exposure, researching subject matter and teaching the topic a number of times, and in-service training or professional development. Many of the other factors outlined above determined teachers’ degree of confidence, and therefore, whether teachers felt out-of-field or not.

(23) I’ve generally found that when you are coming into a new area for which you haven’t been trained, there’s obviously a bit of apprehension at first, but once you get your teeth into it, and with the support you receive from the school, you can approach it more confidently. [B4:44]

The data has shown a variety of perspectives, some maintaining that tertiary qualifications in an area remains a necessity to teach a subject effectively, no matter how much experience one has teaching the subject; others felt exposure and practice equipped them with the necessary knowledge. Gaps in content coverage during their undergraduate degree made it difficult for some teachers to feel confident teaching the content. For example, for B1, a lack of understanding of the general ideas in chemistry due to
specialised training in only one area of chemistry, lack of confidence in her own ability, and a history of not experiencing a high degree of success has meant that she has had to ‘re-teach’ herself through extensive research to enable her to teach. This has led to her feeling out of field at the beginning of her career, despite being technically in field:

As I got into it I got more confident but anything higher than Year 9 or Year 10, even Year 10 I would struggle without a lot of background and research and practice. Probably chemistry to be honest even though it’s one of my methods, it was not something that I was fantastic at at school. And so I’ve sort of had to re-teach myself some things because you’re only focusing on, well for me it was environmental chemistry so it wasn’t all the other bits and pieces like stoichiometry and things like that. But now that I’ve done it for three years you get better at it. [B1:38]

On the other hand, some teachers used their background or knowledge of the content as a justification for feeling in-field when technically out-of-field. A4 was perhaps the most adamant that qualifications had little bearing on her capacity to teach mathematics. A history of success in high school, a mother who was a maths specialist teacher, and an interest in the subject, was regarded as a strong basis for feeling in-field:

I was interested in doing Maths as a method for my DipEd anyway but I technically wasn’t able to. I did a lot of it in school, so I was keen to teach Maths anyway. I was glad that I was able to get some Maths classes…In Year 12 I did Methods and Specialist, so I pretty much went as high as you could get. So I felt that I had enough qualifications to teach at least junior Maths in schools even though I didn’t do much Maths in uni. [A4:19,23]

To be honest, I think the method training gets more credit than it should. It’s certainly helpful, but I don’t think any subject should be ruled out just because you haven’t done it as a method. Maybe you would have a few other ideas if you did it as a method, but I don’t think you’re too overly disadvantaged if you don’t. [A4:121].

Teacher commitment was manifested as seeking better ways to engage students, devoting time to planning, identifying oneself as a teacher of the subject, and showing an interest in the subject. The circumstances of teacher allotment are relevant here. The level of commitment of three teachers are contrasted below:

(30) History is out of field, but it was an interest area… When I first came here I had two maths classes, and then the science teacher left, so I took more science, and I’ve only – in the last three years – started to teach maths again. And I asked to do that; because if I wanted to get a transfer I thought that having a bit of maths behind you would help. [B3:32,38] (Repeated from “Contextual Factors”)

(19) [I don’t have the] drive to do it. Coz I don’t like it. Only one of the four subjects I teach will be maths. Because I know I’m kind of filling in I don’t have the drive to go and find out how to do it properly. And I’d prefer to spend my time doing my other classes and making sure that they’re spot on, rather than junior maths. [C1:108]

(22) If I had to put myself on a scale, from the start of teaching out of field to now, I would say that I’m probably sitting at a 7 now, whereas I was probably sitting at a 3 at the start. Because I had the enthusiasm, but I needed to do some research. I would happily, if they said to me: ‘Can you teach Year 7 and 8 Maths next year?’ I’d say: ‘Yep, not a problem.’ [C2:188]

B3’s commitment to teaching History arose out of an interest, and contrasts starkly with C1’s lack of commitment or ‘drive’ to improving his Maths teaching where he was ‘just
filling in’. C2 was committed to professional learning required to develop expertise and confidence in her teaching.

Teachers tended to assume interest in the in-field subject partly because their identities were bound up in a background of interaction with the subject; they were thus more likely to identify themselves in a particular way, for example, ‘I am a maths-trained teacher’. In contrast when teaching out-of-field, there is no taken-for-granted alignment with the subject, so justification for teaching a subject must come from somewhere else in the teacher’s background, some positive interaction, interest or pattern of success that enables the teacher to relate to it, or identify with it. Problems arise for teachers when this socio-historical interaction with the subject is missing or negative or ambivalent. Wanting to do the best thing for their students, a pedagogical imperative as distinct from their personal interest in the subject (Darby, 2009) becomes a driver for those teachers who have little passion for the actual subject. Teachers who are passionate about their students’ education spend time preparing and searching for materials, seek support, and act professionally in their conduct. But what happens if out-of-field teachers are not able to devote time or energy to acquainting themselves with the new knowledge, modes of enquiry or teaching strategies, or make links between engaging activities and the related concepts? Various reasons, such as short term appointments, devotion to preferred subject areas, lack of autonomy, lack of time or support, or simply lack of interest or motivation, can make it difficult for the out-of-field teacher to embrace this pedagogical imperative and thus cater for student learning needs.

Another personal resource needed by out-of-field teachers was adaptability. B4 explains his need to adapt his knowledge of teaching to the new setting:

(8) I’m not a trained maths teacher; and obviously there are different ways of delivering the content, and so I’m just relying on my experience, which is drawn from my traditional teaching areas and I apply and adapt that to the new area. I believe it’s worked successfully, but there’s always that question of how would a qualified maths teacher of some years experience approach this? So you’re really relying on your nous your – not cunning, but – your innate experience I think. [B4:56]

Teaching is a dynamic career, where broad scale and local changes mean that teachers are required to continually learn new things and adapt. Teachers find themselves in situations where they must “do research”, learn from colleagues, and be adaptable. How a teacher copes in these situations is critical to both their practice and their professional identity. The level of autonomy or choice that teachers have can influence their capacity or willingness to adapt. Teachers’ capacity to cope with changes associated with out-of-field teaching can be defined as adaptive expertise. Adaptive expertise is the ability to apply knowledge effectively to novel problems or atypical cases in a domain (Holyoak, 1991). It encompasses a range of cognitive, motivational, and personality-related components, as well as habits of mind and dispositions. As teachers adapt to different educational environments, they construct their knowledge and beliefs “from the perspectives of self-in-relation-to-social context” (Simmons et al., p. 948). Expectations placed on teachers by the school context, such as having to teach out of field, require teachers to adapt to different educational environments. Simmons et al. explains that “how the environment in which one functions, especially with regard to the expectations of others, contributes to teachers modifying their actions and eventually their beliefs” (p. 932). If teachers are to adapt to the new field or domain, conditions must be conducive for teachers to make the necessary adjustments to not just their knowledge, but also their perceptions of themselves as teachers of the subject.
In this study, teachers are seen to display adaptive expertise when they adapt to teaching outside their fields of expertise. Some of the teachers in this study welcomed the opportunity to teach a new subject and were willing to forego efficiencies developed in-field and embrace the required innovation to adapt to the out of field setting. Other teachers opted for a high degree of efficiency in the preferred field and were therefore resistant to change. C1, who was negative about teaching maths, had been willing to diversify into ICT through an organised reaccreditation program, yet was unwilling to pursue the same in maths for a number of reasons, but principally, because he was less interested in maths.

Teachers responded to their out-of-field allocation in a variety of ways, and their response demonstrated their commitment to the subject, beliefs about their role, and identity as teachers. Teachers can be situated on an Adaptability Scale to reflect their level of commitment and their identity in relation to the subject. Some teachers, such as C1, can be identified as “just filling in” where they have limited or no identity in relation to the subject, possibly because of a history of failure or negative experiences, they can’t relate to it, they lack interest, or lack knowledge of how to teach it. Others, such as A4 and B3, could be seen as “pursuing an interest” where they expanded their identity to being a teacher of that subject due to a personal interest and high level of self-efficacy arising from positive historical interactions with the subject. Others, such as C2, could be seen to be “making the most of it” as they endeavour to improve their practice so as to engage students through interesting, contextualised learning experiences, and coherent and well-sequence units.

Conclusions and Implications

While the term out-of-field has a technical meaning relating to discipline- and method-related qualifications, the BBF Model provides a lens to investigate how teachers identify themselves and their practice as being out-of-field. It provides a platform for reconceptualising these experiences as opportunities for professional learning occurring within schools as communities of practice, where teachers are supported and enabled to expand their professional identity. A teacher’s professional identity is organically bound up in their knowledge and appreciation of the subject, and construction is ongoing and contextually dependent. This framework is innovative and critical for informing the development of theory relating to the contextual nature of teachers’ work, teacher effectiveness, teacher identity, and school governance, but more importantly the framework brings into focus the roles that support, context and personal resources play in the success of subject boundary crossings.

This investigation of the personal impact of teaching out-of-field highlights the need for: closer examination of the availability, variety and opportunity for teacher support in rural and regional areas; collaborative approaches to and professional dialogue around teacher allocation; a more complex definition of teaching out-of-field that recognises teacher’s personal resources, context and support; and a focus in teacher education on the skills, knowledge and attitudes needed to increase teachers’ adaptability when faced with having to move outside their domain. Inexperienced teachers who have not yet developed expertise may be less suited to teaching a subject out-of-field; but it is also important to recognise that there are many factors that can impact a teacher’s appropriateness to teach a subject out-of-field that may or may not depend on level of experience or background. Important also is recognition by school leadership of what is involved for teachers when they teach out-of-field, and to be aware of the requisite conditions for teachers to approach instances of teaching out-of-field as opportunities for professional learning, where they are “pursuing an interest” instead of “just filling in”.

References


