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OUTFIELDERS:

AN UNKNOWN QUANTITY IN SECONDARY SCHOOL SCIENCE

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ABSTRACT

Three government reports have noted ongoing shortages of secondary teachers of science, particularly in rural and remote regions. The extent of these shortages is masked by the employment of teachers *out-of-field.*

This study focuses on two beginning primary trained teachers making the transition to secondary science. Compounding the usual difficulties of beginning teachers, these teachers are teaching in multiple disciplines, beyond the level for which they were trained. Additionally, the range of subjects and year levels they teach works against the development of Pedagogical Content Knowledge in any particular area. The metaphor of journeyman is used to consider employers' attitudes to these teachers.

A significant finding was that the very qualities of previous career experiences and personal attributes that led to the employment of these outfielders mitigates against their receiving the support they need.

SECONDARY SCIENCE TEACHING — AN OVERVIEW

The Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA) (2001*),* found the teaching labour market was broadly in balance, although in particular discipline areas (Science, Mathematics and Technology) and some geographical locations (rural and remote regions), there are shortages. Additionally, the real extent of the shortage of science teachers is hidden by the use of teachers teaching out-of-field (Committee for the Review of Teaching and Teacher Education, [CRTTE], 2003). The number of science teachers coming into the profession is expected to remain, at best, at the current level, whilst other English speaking countries with similar shortages recruit in Australia, offering very attractive rates of pay (Department of Education, Science & Training [DEST], 2002).

Some education jurisdictions solve these shortfalls by exercising internal flexibility (MCEETYA, 2001), to employ effective[1] teachers from other areas as teachers of secondary school science. Regrettably, such teachers lack content knowledge, and appropriate pedagogies for teaching science. If this process of filling secondary science teaching positions with *outfielders*[2] is to achieve more than filling timetable slots, these teachers' content and conceptual knowledge in science needs strengthening, and their repertoire of appropriate pedagogies need to be developed. In other words, the teachers' Pedagogical Content Knowledge (PCK) (Shulman, 1986) must be extended.

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[1] In this paper, "effective" describes teachers who within their teaching area, hold the appropriate content knowledge, pedagogy, skills, knowledge of curriculum and students that usually lead to students demonstrating the expected syllabus outcomes.
[2] I coined the term 'outfielders' in 2002 to describe the group of teachers I had chosen to focus on for my study. In 2003 CRTTE used the term "teachers teaching 'out-of-field'" to describe teachers in the same situation—teaching subjects at a level above, or outside, their area of qualification (JB).

BACKGROUND STUDIES

We are not alone

In the United States, difficult to staff schools are marked by socio-economic factors, and/ or high numbers of minority students, often in very large cities. Australia has some such schools, but the worst problems are in rural and remote regions. Nevertheless, many of Australia's rural students share with disadvantaged American students the characteristics of low socio-economic and/or minority backgrounds.

Responding to the No Child Left Behind policy (Academic Improvement And Teacher Quality Programs Office Of Elementary And Secondary Education, U.S. Department Of Education, 2003) Darling-Hammond and Sykes (2003) reported "widespread use of under-prepared teachers…mainly for disadvantaged children in schools that suffer from poor working conditions, inadequate pay and high teacher turnover" (p. 2). Yet, the United States produces far more teachers than it needs. Shortages are in particular areas.

Two key factors affecting teacher distribution were identified by Darling-Hammond and Sykes (2003): the departure of beginning teachers; and shortages in particular subject areas. They found that beginning teachers received very little support. Failing to retain beginning teachers caused high staff turnovers, which "particularly affect schools serving poor and minority students" (p. 16). Additionally, there are economic impacts. Different industry models put the annual cost of early teacher attrition in Texas at between $329 million and $2.1 billion per year (Benner, 2003).

As in Australia, it is in the fields of science and mathematics that shortages occur. Darling-Hammond and Sykes (2003) suggest that this results from the larger wage disparity

between earnings as a teacher and opportunities outside teaching, in these areas than for other subjects.

H2 **Does it matter?**

That expert teachers directly influence student outcomes was established by Ferguson (1991) in a study of 900 Texas school districts finding that combined measures of teacher expertise were the most influential factor in literacy and numeracy results of children from Year 1-11, including parental income. Wenglinsky (2002), in a study of 7 000 Year 8 students also found their achievements to be influenced by their teachers' content and teacher education backgrounds. Again this effect outweighed that of socio-economic backgrounds.

If students in hard to staff areas are taught by teachers lacking content knowledge and teaching experience, it clearly impacts on their learning.

Beginning teachers

Most beginning teachers receive little support. Zeichner, Tabachnick and Densmore (1987) reported that 'the view of the majority of teachers and administrators, is that any fully licensed teacher should be expected to be a "completed" teacher, fully capable of meeting all the obligations and demands of a classroom' (p. 38). More recently, Elmore (2002) stated that 'despite massive evidence to the contrary…the prevailing assumption is that teachers learn most of what they need to know about how to teach before they enter the classroom' (p. 5).

The need for support for beginning teachers has been established by a range of researchers. A survey of beginning teachers by Khamis (2000) found that support in the first year was critically important. CRTTE noted the need for '[g]reatly improved programs of support, induction and mentoring for beginning teachers' (2003, p. xi) to retain trained teachers of science. Within Australia, lack of support contributes to the resignation of up to 25% of beginning teachers within the first five years of teaching (CRTTE).

However, there are 'few formal mentoring programs for beginning teachers' in Australia (Appleton, 2003, p. 20) and in the United States, the National Centre for Education Statistics (NCES) (1999) noted that only 20% of beginning science teachers participated in induction programs.

Although beginning teachers cannot always identify their own needs 'it is through *recognizing* and *confronting* the difficulties and dilemmas of practice that the development of autonomy and self-reliance will best be stimulated' (Asoko, 2000, p, 81, italics added). Beginning teachers often draw on their own experiences of being taught and though they may want to use inquiry-based approaches, many lack 'a clear image of what [that] might look like in a K-12 classroom' (Lynch, 1997, p. 7).

Science teachers have particular problems, caused by the range of tasks that they encounter (Luft & Patterson, 2002) and 'the demise of many of the local advisory teachers' (Dillon, 2000, p. 103) has reduced teacher access to sources of effective practice. For science teachers to use the inquiry-based approaches to teaching common to contemporary science curricula, it is 'critical' that they are supported during their first three years (Luft & Patterson, p. 267). Luft and Patterson proposed that successful induction should be long

term (two to three years); address beliefs, practice, science and science teaching; and utilise collaborations between universities, school districts, and experienced teachers.

Teaching is claimed as a professional activity (e.g., Shulman, 1987), yet the comparison to tradespeople made by Berliner (1987) may be more valid:

> In education there is a very ill-defined system for passing from apprentice to journeyman to master of the teaching field. First-year teachers are often given equal or more difficult assignments than 10-year veteran teachers, and they are expected to perform as if they are very experienced (p. 60).

Pedagogical Content Knowledge (PCK)

Many researchers identify PCK as the hallmark of an effective teacher (e.g., Appleton & Kindt, 1999), yet teachers beginning their careers as outfielders have limited knowledge of the content they are to teach. Veal (2001) cites teachers' content knowledge as the first priority of the Association for the Education of Teachers in Science (1998), National Science Teachers Association (1998) and National Research Council (1996).

Shulman's (1986) construct of PCK built on his belief that teachers must have 'a depth of understanding with respect to the particular subjects taught' (p. 9), to state that:

> The key to distinguishing the knowledge base of teaching lies at the intersection of content and pedagogy, in the capacity of a teacher to transform the content knowledge he or she possesses into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by the students (p. 15).

Pedagogical reasoning begins with teachers' ability to 'critically understand a set of ideas, a piece of content, in terms of both its substantive and syntactic structure….[and] the relationships between that piece of content and other ideas' before they can 'transform' the content into a teachable form (Wilson, Shulman & Richert, 1987, p. 119f). Feynman (1996) agreed. '[T]he standard by which he measured whether something was really understood' (p. xxii) was his ability to reformulate and teach the information to young students.

As yet, 'the amount of subject matter knowledge really needed to help children learn is a contested issue' (Kennedy, 1998, p. 253). Additionally we 'know very little about how to enhance pedagogical content knowledge' (Cochran, 1997, unpaged), although indications are that PCK needs to develop in relation to specific content or topics (Loughran, Gunstone, Berry, Milroy & Mulhall, 2000). These points are pertinent if we are to address Shulman's (1986) question, 'How does the teacher prepare to teach something never previously learned?' (p. 8).

Teachers cannot develop professionally alone. Experts, mentors and critical friends are needed to help with the long-term hermeneutic cycle of reflection and metacognition necessary to develop PCK in new teaching areas (Bell & Gilbert, 1996, Harrison & Nicholls, 2002).

Professional development

Schools, however, often fail to provide models of effective practice for beginning teachers (Lynch, 1997). It seems that they do not consider the development of teachers as their responsibility. and 'the existing structure and culture of schools seems better designed to

resist learning and improvement than to enable it' (Elmore, 2002, p. 4). Elmore argued that accountability is a reciprocal process in which employers have the responsibility to provide teachers with the capacity to meet expectations held for them. Dillon (2000) also saw teacher development as a management responsibility, whilst noting that in the current climate of accountability 'teachers are under pressure to deny they have problems' (p. 101).

In order to translate into effective classroom practice, professional development must meet teachers' needs. Top down imposed change (Lynch, 1997) or 'training' teachers to implement compulsory curricula do not empower teachers to meet their individual professional needs (Gilbert, 1994). Similarly undertaking study for higher qualifications does not result in classroom change (Bell, 1994, p. 493).

Successful professional development most often occurs with individual teachers or small groups, in schools or classrooms, and based on observations of actual teaching (Elmore, 2002). Collegial relationships with mentors were found to change teaching practice as teachers viewed these changes as 'more relevant, realistic, and desirable than those prescribed by others' (Keys & Golley, 1996, p. 243).

Outfielders

Teaching out-of-field has been mentioned in the context of teachers normally considered as exemplary, teaching in unfamiliar areas where:

- 'errors of fact were made and opportunities to elaborate on student understandings, and to diagnose misunderstandings were missed' (Tobin & Fraser, 1990, p. 19);

- teachers actually created misconceptions in students, and failed to recognise existing misconceptions (Happs, 1987);

- teachers showed more misconceptions and misunderstandings, used less relevant analogies and examples, and demonstrated less organised understanding (Hashweh, 1987).

In the United States, about 44% of middle school are taught by teachers without tertiary qualifications in the subjects they teach, while 22% of secondary school students are taught by teachers who are uncertified in their teaching area (Academic Improvement And Teacher Quality Programs Office Of Elementary And Secondary Education, U.S. Department Of Education, 2003). In Australia, conditions are unlikely to be better, although the picture is less clear. A Tasmanian Department of Education survey in 2000, cited 34% of secondary science classes being taught by teachers who had no tertiary science training (Melville, 2004). CRTTE reports the following submissions made to it:

- 'Schools may not be able to offer higher level maths and science courses' (Association of heads of Independent schools of Australia).

- Some schools 'manage to obtain teachers who would not be acceptable in more affluent areas because of their poor training' (Prof. Elliott, University of Canberra).

- There is 'a critical shortage of teachers in the area at secondary level' (Technology Education Association of Victoria).

CRTTE (2003) concluded that 'teachers teaching "out-of-field" hides true shortages' (p. 8) and it is not possible to determine how widespread the practice is.

Other solutions

Solutions to teacher 'shortages', other than outfielders, must be considered. Australia's education systems, operating at state and territory levels, offer considerably different levels of incentives to attract teachers to areas of need. These range from Queensland where payments made are as recompense for travel during vacations or for health reasons, but there is no actual compensation for isolation, to Western Australia, where teachers at the most 'difficult to staff' schools can receive over $18 000 pa tax free and free accommodation amongst their benefits (http://education.qld.gov.au, www.eddept.wa.edu.au).

Long term solutions may better be achieved by returning to ways of attracting new teachers. Many teachers prefer to work close to where they grew up or went to college ((Darling-Hammond & Sykes, 2003). In Australia our most isolated schools are often in Indigenous communities, In its review of Indigenous education, the Northern Territory Department of Education (1999) stated that although there are not system wide data available, there are some regional statistics that 'verify the widespread understanding that Indigenous teachers are in place far longer than non-Indigenous teachers' (p. 76). It is therefore logical that extending university campuses to regional and rural areas and offering increased incentives for Indigenous applicants, should help.

Some regional universities have already met this challenge. Central Queensland University students can gain a teaching degree from Pomona, Bundaberg, Gladstone, Rockhampton, Mackay and Emerald campuses (www.cqu.edu.au accessed 22nd April, 2004). Batchelor Institute of Indigenous Tertiary Education (BIITE) in the Northern Territory has innovative teacher education which even in its full time version is offered as short (up to 4 weeks)

blocks of residential study at Batchelor (near Darwin), Alice Springs and, beginning this semester, at a community (the courses are based at the lecturers' places of residence). Between blocks, students return to their homes to study. This is a practical compromise in a sparsely populated jurisdiction that could not sustain multiple teaching sites. It is workable because the Institute funds their students' expenses (Melody Bat, Course Administrator, Education and Humanities, BIITE, personal communication, 22nd April, 2004.). If more institutions offer opportunities for pre-service teachers to study close to home, this should impact on the number of teachers available and willing to teach in rural, regional and remote areas.

To attract teachers to subject areas where there are shortages, Darling-Hammond and Sykes (2003) state that mathematics and science graduates who choose teaching over other career options "suffer larger wage disparities than those for English and social studies" (p. 16). This was raised in Australian media this year. The Weekend Australian editorial (Solving a problem in school mathematics, 2004) called for higher wages for teachers of subjects "that are hard to learn and tough to teach, such as maths" and The Courier-Mail reported Professor Peter Andrews' statement that science teachers need to be paid "sufficient money to give them prestige (Livingstone, 2004, p. 7). Teachers' unions do not agree. For example, the Queensland Teacher's Union's Vice President, Steve Ryan (personal communication 20th April, 2004) believes support for differential pay rates is counter-productive to their aim of better salaries for all teachers. Governments must negotiate with unions to find acceptable ways of attracting and retaining high quality science, mathematics and technology graduates as teachers.

Summary

Teacher shortages in particular areas of need, rather than a shortage of teachers per se, is a serious problem in the United States and Australia. Although research has established that teacher expertise is the single most important factor in student achievement, provision of support for beginning teachers is the exception not the rule. Beginning teachers of science have additional problems due to the nature of their subject. Although how beginning teachers' PCK can be enhanced, and to what extent content knowledge needs to be developed, is not clear, in-school small group or individualised professional development using critical friends or mentors, has been effective. Professional development must be targeted at teachers' needs to translate into effective classroom practice.

The use of outfielders in science education is an established, ongoing practice with a number of inherent problems.

THE PROJECT

This paper focuses on the pilot study of the author's Doctoral study, and seeks to answer the question:

> How can teachers who are either teaching academic subjects outside their original specialisation or are underqualified in those fields, be assisted to improve their knowledge and competencies to teach these subjects? (DEST, 2002, p. 28)

The project aims to develop, trial and implement mentor-mentee educative models to enhance beginning teachers' PCK. The participants in this pilot study are two such

beginning teachers, teaching in secondary schools after graduating from a primary preservice course.

DESIGN AND METHOD

For this paper, two beginning teachers were interviewed, and observed teaching secondary science. The teachers chosen were recent graduates whose situations not only were known to the authors, but had been a factor in the decision to research this topic. It seems that employers target high achievers as they could be expected to strive to develop their content and conceptual knowledge, pedagogy, and the many other facets of teaching that combine to become the PCK of an experienced teacher.

The primary data collection instrument was the researcher as interviewer and observer in the teachers' classrooms (Robson, 1993). Audio-tape recordings supplemented observations and notes, and a reflective journal was kept of all interactions. The research commenced with the researcher interviewing the teachers, and during the following weeks the teachers were observed and interviewed as they taught their regular science classes. The resulting data were analysed inductively, in a search for recurrent themes and categories, as well as for discrepant events.

Qualitative research methods are appropriate for collection of data focusing on people's 'experiences, opinions, feelings and knowledge' (Patton, 1990, p. 244). Interpretive methodology and case study are recommended for educational research by many authors (e.g., Denzin & Lincoln, 1994,) to utilise multiple sources of evidence to garner a comprehensive perspective. Case study is advocated to document practical experience

(Merriam, 1998), particularly regarding perceptions of need. In keeping with the constructivist paradigm, case study provides thick description to allow readers to participate by making judgments in relation to their own experiences (Merriam).

CONTEXT

In Australia, incentives to attract teachers to geographic areas of need are long established. The states and the Northern Territory offer various additional payments to teachers to compensate for living in isolated areas. These include tax-free payments to work at difficult to staff schools, two or three trips annually to the capital or a provincial city, relocation expenses, subsidised accommodation, extra leave, study leave, and reimbursement for travel for health or personal business reasons (http://education.qld.gov.au, www.det.nsw.edu.au, www.teaching.vic.gov.au, www2.education.tas.gov.au, www.eddept.wa.edu.au, www.decs.sa.gov.au, www.teaching.nt.gov.au, all accessed 5th April, 2004).

Yet these established measures have not attracted sufficient highly qualified staff to non-urban areas. The following case studies report the experiences of two teachers working in regional cities that are neither rural nor remote. Yet as teachers qualified to teach the required subjects could not be found, outfielders were employed.

This study was conducted in two secondary schools in regional Queensland. The focus is the experiences of primary trained teachers as they teach secondary science. A brief background to Marion's and Drew's situations will help to establish their contexts.

As mature age students, they qualified as primary school teachers, specialising in Science and Mathematics. Marion graduated with First Class Honours, Drew with Distinction. Permanent employment as primary school teachers was not available in their area, and their family situations precluded relocating,

Marion registered for supply work, working in a variety of situations for periods ranging from a single day to six months, over an 18 month period. She then applied and was accepted for employment as a junior secondary teacher. At the time this study began, she was beginning her second year of regular employment.

Drew worked in primary schools for six months for varying short periods. At the time of this study he had begun the year as a secondary teacher contracted for Term 1, later extended to Term 2.

DATA, INTERPRETATION AND DISCUSSION

Personal attributes

The data point to some factors that may hinder Marion's and Drew's development into expert teachers of secondary science, and others which could help.

Drew and Marion were considered the best available people to fill their positions. Both were mature age students notionally qualified to teach to Year 10, graduating with exceptional marks and an S1 rating from Education Queensland[3].

Marion applied for a position secondary teaching at a non-government school. She believes that the 12 High Distinctions she received for Science and Mathematics at university impressed the principal, perhaps more than it should have, and that the principal thinks 'I'm more than qualified to do the job'. As a supply teacher, she established a reputation for being willing to teach any subject.

My perception is that Marion and Drew needed steadier employment after four years as students. They had impressive CVs and excellent interpersonal skills. As Marion said, 'I probably can manage to sound quite convincing and confident.' Drew too, thinks that the school staff sees him as 'a very confident, capable, experienced teacher' despite his explanation 'that not only am I a beginning teacher, but I'm primary trained.'

As recently trained teachers, Marion and Drew bring a contemporary approach to their teaching. Both try to use constructivist methods of teaching. Drew related Newton's first law to skateboard accidents to link with students' prior knowledge, and had students ride a bicycle around the laboratory. Marion went beyond a textbook experiment for students to bring water to boiling point, to continue heating and consider what was happening.

[3] In Queensland, the state education department interviews preservice teachers during their final practical teaching placement to determine their suitability for employment. Based on responses to a very comprehensive list of selection criteria, interviewees are rated on a five point scale from 'outstanding applicants'(S1) to 'unsuitable applicants' (U/S).

Both are parents of teenage children and relate well to teenagers. They see their students holistically. Drew considers the students 'not so much adults but as individuals….my attitude is this is the work that we have to get through together.' Marion has 'a great desire to help the students become life long learners, independent women, not second-class citizens.'

Marion and Drew bring considerable life experience to their teaching. Marion previously worked as a nurse and Drew was a motor mechanic. Their professions provided solid groundings in aspects of science content. Drew taught two set units of science, 'Motor cars' and 'Road science', drawing on his previous experience about 'acceleration, velocity, reaction distance, inertia'. He felt that he established credibility by discussing real life examples such as crumple zones, air bags, and collapsible steering columns. Marion has not yet taught biology, but during a SOSE lesson she helped her students to understand blood circulation through the heart.

However, it would seem that the very qualities and experience that Marion and Drew bring to teaching tell against them. Although both have made it clear to their colleagues that they are primary trained beginning teachers, it would seem that their confidence, willingness to 'have a go' at most subjects, and general air of capability, mean that other staff perceive them as equals rather than as beginners.

Employment conditions

Initial employment.

Drew and Marion were employed on various contracts after university. Their initial contracts, often for a single day, did little towards development of PCK. There was no possibility for pre-planning, no 'big picture' of what was being taught, no opportunity to develop concepts or familiarity with students.

Current classes.

Marion teaches six different classes across five subject areas and three year levels. She teaches no multiples of classes. Drew teaches Mathematics and Science to four different classes across three year levels. His school streams students by ability, so there are no repeat classes.

Table 1. Current teaching duties

Drew	Marion
Year 9 Mathematics, extension	Year 8 Science
10 Science, core	9 English
12 Mathematics, trade & business	9 SOSE
12 Science, Multistrand	11 Mathematics
	11 Consumer Mathematics
	11 Early Childhood Studies

Multistrand Science is a Queensland Studies Authority (QSA) 'authority' subject, contributing to a university entrance score, whilst the other four senior subjects are 'authority-registered', not contributing to university eligibility (QSA, 2003). With one

year's less experience than Marion, Drew is teaching two senior classes, one of which influences the students' university eligibility.

With so many classes to prepare for, Marion felt that last year she was simply 'sucked into the system and floated along'.

> Apparently it's part of the process. I've been warned to do as much as I can and be very useful and after a couple of years, I can say I've had enough of these other subjects, I want to do… so I'm serving my apprenticeship I suppose (Marion).

Support.

Marion and Drew received differing levels of support. Drew was employed on a day's notice. The departing teacher left 'two scribbly bits of A4 paper sticky-taped behind my desk… no planning for me to pick up on.' Another science teacher 'gave me the science text book, said, "Here's the chapter," and basically walked away and left me to it.'

'I wasn't shown any sort curriculum plan… any requests were a snatched couple of minutes, or I furiously wrote notes while one of the other science teachers gave an overview of what he would be doing. I didn't have an assessment piece to work towards to know what sort of depth of understanding they needed.' Drew set and marked his own assessment, without any moderation. Whilst this allows freedom, it does not set expectations, provide structure, or provide accountability.

For term 2, Drew's Head of Department had been on leave. Drew was given a new science class and again, one day's notice of the chapter he was to teach to this class.

Marion works in a more structured environment. Her units are based on the textbook, but additionally, she is given a list of focus areas, and a set year level test. She considers this too structured. 'We all do the same thing. I find that hard because sometimes I think they're things that I wouldn't focus on.'

Perceived constraints

Drew's and Marion's perception of constraints to their effective teaching of science is noteworthy.

Their structural concerns were mentioned above. Drew feels that lack of structure leaves him without a teaching focus or means to measure his effectiveness. Marion feels constrained by the proscribed teaching emphasis and traditional pen-and-paper tests.

In recognising her limited pedagogy, Marion acknowledges 'I need ways of showing it or explaining it that are different to what I currently use….I would like to see what other teachers do, how they get a point across.' She wants activities for students to do because 'when they can see it for themselves it means a lot more than reading about it or being told.' She is not looking for 'activities that work' as Appleton and Kindt (1999) use the term, but she would like 'a bag of tricks…that the students can work through to make them think'. In short, she needs to develop her PCK.

Drew found that PCK developed training apprentices did not transfer to teaching in a classroom. He would have liked to 'go out and do some real work'. Drew felt that if a car had been available, discussions about seat belts, speedometers etc, would have been more fruitful. Drew too would like more ideas for 'actually doing things' whether in 'small

groups in the laboratory, or actually doing some activities outside without major blood loss.'

It is notable that neither teacher raised limited content knowledge as a constraint. Marion was 'initially concerned that I might not know enough, so I read the text book from cover to cover…. it's all stuff that I know a little bit about, and I see myself learning with the students'. Drew had not yet had to teach a unit outside his particular areas of knowledge.

DISCUSSION

Personal attributes

The personal attributes that Drew and Marion bring to their teaching help them to cope. However, these qualities seem to work against the provision of support for them at either an administrative or work-face level.

As Zeichner et al (1987) and Elmore (2002) found, they are considered to be 'more than qualified' (Marion). Their willingness to have a go at teaching any subject, appears to be perceived as evidence of competence when it is more likely as Dillon (2000) found, evidence of their desire to remain employed. Knowledge from their previous employment also could be misinterpreted as evidence of understanding a broad range of sciences. Their positive relationships with and ability to manage students add to the appearance of teaching experience, and show that aspect of their PCK developing well.

Although fellow staff know that Drew and Marion are beginning teachers, they do not appear so. This seems to mean that they are even less likely to be offered assistance than

most beginning teachers. Something of a 'Catch 22' (Heller, 1996) operates, exacerbated by the absence of support programs for beginning teachers generally.

Employment conditions

Marion and Drew began their teaching fulfilling short-term contracts, and their performances as short-term employees probably led to their current more extensive contracts. However, just as their personal attributes may work against the provision of support, their demonstrated willingness to teach whatever was required, may have similar ramifications.

Now that they are employed longer term, they teach a range of subjects, with no duplicate classes. Marion referred to this as 'serving my apprenticeship'. Perhaps the medieval term of 'journeyman'[4] raised by Berliner (1987) is more appropriate. 'A worker on a journey toward mastery of the trade. No longer an apprentice, the journeyman sharpens and hones skills that will later allow him or her to take on greater responsibility' (http://www.thetask.org/journeyman/about.htm accessed 12 June, 2003). This is an apposite description of the beginning teacher's circumstances.

Other more diverse meanings exist. Simpson and Weiner add that the journeyman works for daily wages, and give a second more depreciatory meaning of one 'who is not a 'master' of his trade….who drudges for another' (1989).

It would seem that various understandings of 'journeyman' are used by our education systems. The employment of beginning teachers is often literally for a day's wage at a

[4] The sexism of this medieval term is noted, and I hope to find a politically correct way of using it.

time. The longer contracts which Marion and Drew now have, could be seen as fulfilling 'drudge' work that permanent staff are unwilling to undertake.

The extent to which outfielders are employed is demonstrated by Drew's teaching of a Year 12 Multistrand Science class. It is not unexpected, that these teachers, notionally qualified to teach to year 10, could be considered able, to teach middle school science adequately. It is astounding that such a teacher has been allocated a Year 12 university entrance subject for a full term with no support provided.

Perceived constraints

Both teachers acknowledged that their restricted range of teaching approaches, explanations and activities limited their ability to teach effectively. This is the area that they perceive as their most important need for support.

Interestingly, neither mentioned the need for assistance with content knowledge. Although they readily acknowledge gaps in their scientific content knowledge, it dos not concern them. They believe that that they can learn and adequately comprehend new content, but need help with ways of 'transforming' (Shulman, 1987) that content into pedagogical approaches. This is not supported by the literature. Wilson, Shulman and Richert (1987) indicated concerns about the levels of substantive and syntactic understanding needed to teach effectively, and Feynman (1996) believed that transformation of content was possible only with sufficient understanding.

Implications

Outfielders are not a problem; they are a symptom of a problem. However, if the American figures (22% of secondary school students taught by outfielders) were applied to Australian conditions, what might that mean? Evidence indicates that the subject areas involved are likely to be science, mathematics and technology, that students most affected are in the higher year levels, and that students in rural areas are even more likely to be affected (e.g. Darling-Hammond & Sykes, 2003, DEST, 2002, Weiss, Pasley, Smith, Banilower & Heck, 2003). Figures for Queensland Year 12 student participation in these subject areas in 2001 are provided in Table 2 using figures taken from Education Queensland, 2002 (?).

[insert Table 2 about here]

Clearly the variations that could result in 22% of these students being taught by outfielders are infinite. But to put this in perspective, these variations would be the *equivalent* of:

- almost every student enrolled in Queensland in Multistrand Science; or
- almost every student enrolled in Queensland in Physics and Mathematics C; or
- every student in rural Queensland enrolled in Information Technology and Processing, Mathematics C, Biological Science, Chemistry and Physics.

The ramifications of situations such as these for both equity in educational access, and our society's place in a knowledge economy, call for urgent consideration. Effective action to attract and retain teachers in areas of need must be taken urgently.

CONCLUSION

Outfielders are not a new phenomenon, nor is the need for them likely to go away. Yet their particular problems have not been addressed, and areas of literature that might be expected to be of assistance are not definitive. The amount of content knowledge necessary to teach is contested, and there is limited data about methods of enhancing PCK (Cochrane, 1997; Kennedy,1998).

Beginning teachers working as outfielders can follow three routes:

- They can become part of the 25% of beginning teachers in Australia who resign within the first five years of teaching (CRTTE, 2003).
- They can become experienced journeymen, lacking any area of expertise.
- Or they can develop subject specific PCK and become master teachers.

The qualities which Marion and Drew bring to teaching from their previous experiences, seem to work against their receiving the support which they will need if they are to become master teachers. They need support to enhance their comprehension of content and ability to transform that content into teachable forms, if their students are to achieve scientific literacy. Further research into the particular complexities of teaching as an outfielder is needed to provide insights into ways of assisting the many teachers in this situation to become more effective.

However outfielders should not be seen as the preferred or long term solution to the problem of teacher shortages. Education departments need to develop and share more effective approaches to attract and retain teachers in areas of need.

REFERENCES

Academic Improvement And Teacher Quality Programs Office Of Elementary And Secondary Education, U.S. Department Of Education. (September 12, 2003). *Improving teacher quality non-regulatory guidance: Revised draft*. Retrieved 15 October, 2003, from http://www.ed.gov/policy/elsec/guid/edpicks.jhtml?src=fp

Appleton, K. (2003). How do beginning primary school teachers cope with science? Toward an understanding of science teaching practice. *Research in Science Education, 33,* 1-25.

Appleton, K., & Kindt, I. (1999, March). *How do beginning elementary teachers cope with science: Development of Pedagogical Content Knowledge in Science*. Paper presented at the annual meeting of the National Association for Research in Science Teaching, Boston.

Asoko, H. (2000). Learning to teach science in the primary school. In R. Millar, J. Leach, & J. Osborne (Eds.), *Improving science education: The contribution of research,* (79-93). Buckingham, UK: Open University.

Bell, B. (1994). Teacher development as learning. *International Journal of Science Education, 16*(5), 493-495.

Bell, B., & Gilbert, J. (1996). *Teacher development: A model from science education.* London: Falmer.

Benner, A. D. (2000). *The cost of teacher turnover*. Austin, TX: Texas Center for Educational Research.

Berliner, D. C, (1987). Ways of thinking about students and classrooms by more and less experienced teachers. In J. Calderhead, (Ed.), *Exploring teachers' thinking (pp. 60-83)*. London: Cassell Educational.

Cochran, K. F. (1997). Pedagogical content knowledge: Teachers' integration of subject matter, pedagogy, students and learning environments. *Research Matters- to the Science Teacher, 9702.* Retrieved 24 June, 2003, from http://www.educ.sfu.ca/narstsite/publications/research/pck.htm

CRTTE. (2003). *Interim report: Attracting and retaining teachers of science, technology and mathematics*. Canberra: Department of Education, Science and Training.

Darling-Hammond, L., & Sykes, G. (2003, September 17). Wanted: A National teacher supply policy for education: The right way to meet the "Highly qualified teacher" challenge. Educ*ation Policy Analysis Archives*, *11*(33). Retrieved October 6, 2003 from http://epaa.asu.edu/epaa/v11n33/.

Denzin, N. K., & Lincoln, Y. S. (1994). Introduction: Entering the field of qualitative research. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of qualitative research*. London: Sage.

Department of Education and Training, Western Australia. (2004). *Teaching career information*. Retrieved 5th April, 2004, from www.eddept.wa.edu.au

Department of Education Tasmania. (2004). Retrieved 5th April, 2004, from www2.education.tas.gov.au

Department of Employment, Education and Training, Northern Territory. (2004). *Teaching in the Territory*. Retrieved 5th April, 2004, from www.teaching.nt.gov.au

DEST. (2002). *Review of teaching and teacher education: Strategies to attract and retain teachers of science, technology and mathematics*. Canberra: Author.

Dillon, J. (2000). Managing science teachers' development. In R. Millar, J. Leach, & J. Osborne (Eds.), *Improving science education: The contribution of research,* (94-109). Buckingham, UK: Open University.

Education Queensland. (2002?). *Year 12 participation in selected learning areas, by location and gender, 1998-2000* (sic). Retrieved 2 December, 2003, from http://education.qld.gov.au/schools/statistics/stat-second.html

Education Queensland. (2004). *Employing quality teachers*. Retrieved 5th April, 2004 from http://education.qld.gov.au

Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education.* Washington: Albert Shanker Institute.

Ferguson, R. F. (1991). Paying for public education: New evidence on how and why money matters. *Harvard Journal of Legislation, 28*(2), 465-498.

Feynman, R. P. (1996). *Six easy pieces: Essentials of physics explained by its most brilliant teacher*. Reading, MA: Addison-Wesley.

Gilbert, J. (1994). The construction and reconstruction of the reflective practitioner in the discourses of teacher development.. *International Journal of Science Education, 16*(5), 511-522.

Happs, J. (1987). Good teaching of invalid information: Exemplary junior secondary science teachers outside their field of expertise. In K. Tobin, & B. J. Fraser (Eds.), *Exemplary practice in science and mathematics teaching.* Perth, WA: Curtin University of Technology.

Harrison, A. & Nichols, D. (2002). Enhancing science teachers' pedagogical content knowledge at Biloela SHS. Paper published in *Science works for the smart state* (pp.81-86), State of Queensland: Department of Education.

Hashweh, M. Z. (1987). Effects of subject-matter knowledge in the teaching of biology and physics. *Teaching and Teacher Education, 3*(2), 109-120.

Heller, J. (1996). Catch 22. New York: Simon and Schuster.

Hiebert, J., Gallimore, R., & Stigler, J. W. (2002). A knowledge base for the teaching profession: What would it look like and how can we get one? *Educational Researcher, 31*(5), 3-15.

Kennedy, M. M. (1998). Education reform and subject matter knowledge. *Journal of Research in Science Teaching, 35*(3), 249-263.

Keys, C. W., & Golley, P. S. (1996). The power of a partner: Using collaborative reflection to support constructivist practice in the middle grades Science and Mathematics. *Journal of Science Teacher Education, 7*(4), 229-246.

Khamis, M. (2000). The beginning teacher. In S. Dinham, & C. Scott (Eds.), *Teaching in context*. Camberwell, NSW: ACER.

Livingstone, T. (2004, 23 February). Science training urgent priority. *The Courier-Mail*, p. 7.

Loughran, J., Gunstone, R., Berry, A., Milroy, P., & Mulhall, P. (April, 2000). *Science cases in action: Developing an understanding of teachers' pedagogical content knowledge.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, New Orleans.

Luft, J. A., & Patterson, N. C. (2002). Bridging the gap: Supporting beginning science teachers. *Journal of Science Teacher Education, 13*(4), 267-282.

Lynch, S. (1997). Novice teachers' encounter with national science education reform: Entanglements or intelligent interconnections. *Journal of Research in Science Teaching, 34*(1), 3-17.

MCEETYA. (2001). *Demand and supply of primary and secondary school teachers in Australia.* Canberra: Author.

Melville, W. (2004, April). *Science teachers' occupational community and the implications for non-science trained teachers*. Paper presented at the Annual Conference of the National Association for Research in Science Teaching, Vancouver, Canada.

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. (2nd ed.). San Fransisco, CA: Jossey-Bass.

Northern Territory Department of Education. (1999). *Learning lessons: An independent review of Indigenous eduction in the Northern Territory*. Darwin, NT: Author.

NSW Department of Training and Education. (2004). Retrieved 5th April from www.det.nsw.edu.au/

Patton, M. V. (1990). *Qualitative education and research methods*. (2nd ed.). Newbury Park, CA: Sage.

Queensland Studies Authority. (1999). *Initial inservice materials: Science*. Retrieved 19 June, 2003, from

http://www.qsa.qld.edu.au/yrs1_10/kla/science/pdf/is_mod_7.pdf

Robson, C. (1993). *Real world research: A resource for social scientists and practioner-researchers*. Oxford, UK: Blackwell.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *The Educational Researcher, 15*(2), 4-14.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. Ha*rvard Educational Review, 57*(1), 1-22.

Simpson J. A., &. Weiner, E. S. C. (Eds.). (1989). *Oxford English Dictionary* (2nd ed.). Oxford: Clarendon. *OED Online*. Oxford University Press. 12 June, 2003. (http://dictionary.oed.com/cgi/entry/00124326)

Solving a problem in school mathematics. (2004, January). The Weekend Australian, 10-11 January, p. 12.

Tobin, K., & Fraser, B. J. (1990). *What does it mean to be an exemplary science teacher? Journal of Research in Science Teaching, 27*(1), 3-26.

Veal, W. R. (2001, January). *What knowledge is of most worth for lateral entry secondary science teachers?* Paper presented at the Annual Conference of The Association for the Education of Teachers in Science,Costa Mesa, CA.

Wenglinsky, H. (2002). How schools matter: The link between teacher classroom practices and student academic performance. *Education Policy Analysis Archives, 10*(12). Retrieved 6 October, 2003 from http://epaa.asu.edu/epaa/v10n12/

Wilson, S. M., Shulman, L. S., & Richert, A. E. (1987) 150 different ways of knowing: Representations of knowledge in teaching. In J. Calderhead (Ed.), *Exploring teachers' thinking* (pp. 104-124). London: Cassell Education.

Zeichner, K. M., Tabachnick, B. R., & Densmore, K. (1987). Individual, institutional and cultural influences on the development of teachers'craft knowledge. In J. Calderhead (Ed.), *Exploring teachers' thinking* (pp.21-59). London: Cassell Education.

Table 2. Queensland Year 12 student participation in subject areas in 2001

Subject	Rural students (approx. 5 500)	Urban students (approx. 17 500)	Total student (approx. 23 000)
Information Processing and Technology	10.1%	13.5%	12.7%
Biological Science	26.8%	26.4%	26.5%
Chemistry	18.2%	18.0%	18.1%
Multistrand Science	25.5%	21.1%	22.2%
Physics	15.2%	15.4%	15.3%
Mathematics A	56.1%	54.9%	55.2%
Mathematics B	34.5%	34.7%	34.7%
Mathematics C	6.9%	7.4%	7.3%

Table 1. Current teaching duties

Drew	Marion
Year 9 Mathematics	Year 8 Science
10 Science, core	9 English
12 Mathematics, trade & business	9 SOSE
12 Multistrand Science	11 Mathematics
	11 Consumer Mathematics
	11 Early Childhood Studies