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Science teacher education in Australia: Initiatives and challenges to improve the quality of teaching

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Title: Science Teacher Education in Australia: Initiatives and Challenges to Improve the Quality of Teaching

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Abstract

In this article, we describe how teachers in the Australian school system are educated to teach science, and the different qualifications that teachers need to enter the profession. The latest comparisons of Australian students in international science assessments have brought about various accountability measures to improve the quality of science teachers at all levels. We discuss the issues and implications of government initiatives in preserive and early career teacher education programs, such as the implementation of national science curriculum, the stricter entry requirements to teacher education programs, an alternative pathway to teaching, and the measure of effectiveness of teacher education programs. The politicized discussion and initiatives to improve the quality of science teacher education in Australia are still unfolding as we write in 2014.

Keywords: initial teacher education, early career teacher induction, national standards of teaching, quality of teachers

Running Head: Science Teacher Education in Australia

Science Teacher Education in Australia:

Initiatives and Challenges to Improve the Quality of Teaching

National Debate on Improving Teacher Quality and Initial Teacher Education Reform

In recent years, various ways to improve the quality of school education in Australia have been heatedly discussed. The discussion often starts with the recent international student achievement test scores, such as PISA or TIMSS. Results from the 2011 TIMSS indicate that science achievement from students from Years 4 and 8 have not improved over the past 20 years (Thomson, Hillman, Wernert, Schmid, Buckley, & Munene, 2012), despite various curriculum and education initiatives. In the 2009 and 2012 PISA tests, Australian students performed above the OECD averages, but not comparable to Asian counterparts, such as Shanghai, Singapore, Japan, and South Korea (Thomson, De Bortoli, & Buckley, 2013). For science disciplines, people have shown concerns over the decreasing number of students taking science subjects in the upper years of secondary school to later compete and lead the world economy as quality scientists (Goodrum, Druhan, & Abbs, 2012; Office of the Chief Scientist, 2012). In a knowledge-based global economy, the trailing average scores in international tests, the large achievement gaps between students with different backgrounds, and the decreasing number of science students—all constitute a 'national concern'.

In early 2014, the Minister of Education called for a comprehensive review of teacher education to improve the quality of school teachers, and appointed a panel of experts for the Teacher Education Ministerial Advisory Group (TEMAG) to "provide advice on how teacher education programs could be improved to better prepare new teachers with the practical skills needed for the classroom" (TEMAG, 2014, p.2). As the TEMAG acknowledged, however, the rhetoric of education reform and improving the quality of teachers is not new (Murray, Nuttall, & Mitchell, 2008). There have been many government inquiries and reviews on

teacher education in Australia—both state- and nation-wide—approximately every three years or so. According to Dyson (2005), the reviews of and enquires into teacher education over the past 30 years have focused on the same issues which include "supply and demand, attracting quality recruits and providing quality outcomes for the nations' students" (p.50).

The recent call for reform of the initial teacher education programs in the country is mostly influenced by two studies. First, Barber and Mourshed (2007) analyzed commonalities of best performing school systems in the world, and argued that the most important factor for successful school education to increase student achievement gains is the quality of teachers and instruction rather than the amount of school funding. They highlighted their main points as being "The quality of an education system cannot exceed the quality of its teachers" (p.16) and "The only way to improve outcomes is to improve instruction" (p.27). Second, Hattie's (2009) findings from a meta-analysis of educational studies are also frequently cited, particularly that teachers are identified as the single most important factor in improving students' performance within schools. However, instead of being used to appreciate teachers' contribution towards students' learning and provide resources for teachers' professional development, Hattie's findings have become a ground to blame the quality of teachers for the students' low academic performances (Dinham, 2012; Finger, 2014). One major outcome is a desire by politicians for educational reform by introducing accountability measures to improve teacher quality.

Most recently, the previous federal government established an organization called the Australian Institute for Teaching and School Leadership (AITSL, 2011b, 2013a) to define and maintain the national professional standards for teachers and the national accreditation standards and procedures for teacher preparation programs. Several states recently announced

various teacher education reforms[1] (TEMAG, 2014). For example, New South Wales (NSW) is introducing the strict academic entry and exit standards to initial teacher education programs; Victoria is planning attractive pathways towards graduate entry into teacher education programs for strong candidates with diverse backgrounds; and South Australia has a plan to require new teachers to have a Master's qualification from 2020. Since the TEMAG will release its report later in 2014, we are not certain how the teacher education programs will be reshaped after the review.

The political landscape of teacher education in Australia has been constantly shifting over the years (Mayer, Pecheone, & Merino, 2012). In this paper, we describe and discuss how the various initiatives to improve the quality of teachers are shaping the initial and early-career science teacher education programs in Australian elementary and secondary schools, and discuss some of the challenges faced by science teacher educators.

National Professional Standards for Teachers and Teacher Education Programs in Australia

The Australian federal government has introduced various national standards and established various organizations to improve the accountability of school and teacher education. In 2008, the Australian Curriculum, Assessment and Reporting Authority (ACARA) assumed the role of creating the national school curriculum and assessing students' academic achievement through National Assessment Program (NAP). The Australian Institute for Teaching and School Leadership (AITSL) was formed in 2011 to define and maintain the national standards for teachers and the national accreditation procedures for initial teacher education

[1] Australia is a federation of states (Queensland, New South Wales, Victoria, South Australia, and Western Australia) and territories (Australian Capital Territory and the Northern Territory), each with its own Department of Education and Teacher Registration Board. Each state's education department is responsible for the funding of schools and state curricula. Each teacher registration board has the responsibility of registering new and continuing teachers and accrediting initial teacher education programs in the state.

programs. The critical importance of teacher quality in improving education quality and student achievement is highlighted in the numerous documents of AITSL. They claim that the development and implementation of national professional standards is an effective way to enhance the professionalism and status of teaching.

The Australian *National Professional Standards for Teachers* (AITSL, 2011b) includes "the key elements of quality teaching" (p.1) – "what teachers should know and be able to do" (p.1) at various stages of their careers described as Graduate, Proficient, Highly Accomplished and Lead teachers. The major components of the standards are professional knowledge (content and pedagogical knowledge), professional practice (within school), and professional engagement (within professional and school communities), as shown in Table 1. Whilst written in general terms, these standards and more detailed descriptors indicate what is expected of graduate teachers in their first years of teaching. One aspect of these descriptors is "graduate teachers have an understanding of their subject/s, curriculum content and teaching strategies" (AITSL, 2011b, p.5).

====PLEASE INSERT TABLE 1 ABOUT HERE=====

Because newly graduated teachers are expected to meet the professional standards of 'Graduates', every initial teacher education program provider is required to demonstrate how its initial teacher education program supports its education students in meeting the professional standards upon graduation. The national teacher education program standards and accreditation procedures have been clearly identified in *Accreditation of Initial Teacher Education Programs in Australia: Standards and Procedures* (AITSL, 2011a), in order to "improve teacher quality through continuous improvement of initial teacher education" (p.3) and "accountability of providers for their delivery of quality teacher education programs" (p.3). Following the national standards and procedures, initial teacher education providers

submit their accreditation applications to the state-based teacher regulatory authority every five years and report annually for any changes.

The national program standards and accreditation offer some flexibility in initial teacher education; currently, 48 providers offer 400 accredited initial teacher education programs nationwide (AITSL, 2013b). The programs can be generally categorized into three pathways: (a) an integrated qualification of at least four years of the subject area studies and education studies; (b) combined (double) degrees of at least four years for the discipline and professional studies; (c) a three-year undergraduate degree for the learning area of study plus a two-year graduate qualification in education. For science teacher education for secondary school, the programs can be translated into: (a) Bachelor of Education in Secondary Science Teaching (B.Ed.); (b) double degree of Bachelor of Science in Physics (B.Sc.) and Bachelor of Education in Secondary Science (B.Ed.); and (c) Bachelor of Science in Chemistry (B.Sc.) and Master of Teaching (M.Teach) in Secondary Education.

Initial teacher education must contain two components—discipline studies and professional experiences. For the discipline studies, the National Program Standards state that students should study the learning areas of discipline-specific curriculum and pedagogical studies. For undergraduate elementary teacher education programs, four units each for English and mathematics and two units for science is required[2] while graduate entry elementary teacher education programs require half the amount (1 unit for science). For secondary science teacher education programs, students are expected to attain a sound knowledge in subject areas (for both major and minor learning areas) either from the School of Science or from the School of Education and complete two units of discipline-specific curriculum and pedagogical studies for each teaching area. Units need to be logically

[2] Generally, eight units per year constitute a full-time university study. Each unit is equivalent to four contact hours per week.

sequenced and need to connect theory and practice. However, there is freedom within this document for different teacher education programs to structure the units to suit their own context, whether this be separating science discipline units and science pedagogy units, or integrating them.

Students in initial teacher education programs also need to complete some general education studies such as child development, learning theory, curriculum, assessment, and reflective teaching/educational research. Recently, the national program standards (AITSL, 2013c) added that initial teacher education providers should emphasize the national priority areas in their programs, such as literacy and numeracy; students with special educational needs; Indigenous education; classroom management; and information and communication technology.

For the professional experience component, the Program Standards emphasize the establishment of the collaborative partnership between schools and initial teacher education providers to deliver successful and effective teacher training experiences. Each initial teacher education program must include the minimum of 80 days of well-structured, supervised, and assessed practice teaching for undergraduate programs and 60 days for graduate entry programs. There are no specific requirements for science to be taught during the time that elementary and early childhood preservice teachers complete their practical experience in any capacity.

Examples of Secondary Science Teacher Education Programs in Australia

Because of the recent initiatives to national standards and reviews, universities appear to be currently undergoing reshaping of their initial teacher education programs. For secondary science teacher programs, students generally select one major and one minor teaching areas. For the major teaching area, students need to take three years of the study units along with the teaching methods units to be able to teach senior secondary science subjects (up to Year 12).

For the minor teaching area, students need to take one year of the subject study with the teaching methods units to be able to teach up to Year 10. In a graduate entry program, students need to have completed a Bachelor's degree in the major teaching area, after which they take teaching methods units together with practice teaching or professional experiences.

Edith Cowan University in Western Australia has a large teacher education program. The course structure of the four-year integrated secondary science teaching program (B.Ed.) comprises three parts: general education studies, discipline and curriculum studies (for major and minor teaching areas), and practicum, as illustrated in Table 2.

=====PLEASE INSERT TABLE 2 ABOUT HERE====

The University of Sydney in New South Wales offers a five-year double degree program (B.Sc. and B.Ed.) for secondary science teachers. Like integrated teacher education programs, this double degree program has three components (general education studies, discipline and curriculum studies, and practicum), but it has a stronger emphasis on the science studies and curriculum component, requiring students to take 8-12 units of science (at least 4 units from senior level science) for the major teaching area, 4-8 units of science (at least 4 units from intermediate level science) for the minor teaching area, two units of mathematics, three units of curriculum studies for each teaching area.

Graduate entry teaching diploma programs have been popular for many secondary education students. The University of Melbourne in Victoria offers a two-year Master of Teaching program along with a one-year postgraduate Diploma in Teaching program, which is expected to be phasing out due to the AITSL requirements. For the first year, 18 contact hours per week at a university campus plus two days per week at school placement and one block of 20 days for practice teaching at school per semester. Completion of this program enables the awarding of the Postgraduate Diploma for Teaching. The second year could lead to induction at school with a teacher mentor, conducting an educational research project, or

coursework on a specialized area. After the completion of the second year, students are awarded a Master of Teaching degree.

Examples of Elementary Teacher Education Programs in Australia

Initial teacher education providers in different states across Australia have been able to develop science courses appropriate to their contexts. A significant issue for elementary and early childhood teacher educators is to balance the amount of science content with research-based science pedagogy to improve pedagogical content knowledge of preservice teachers (Hume, 2011; Loughran, Mulhall, & Berry, 2008; Shulman, 1987). The following discussion provides an illustrative example of how teacher education programs meet these requirements within early childhood and elementary degrees.

The University of Notre Dame Australia is a Catholic higher education institution with campuses in Western Australia (WA) and New South Wales (NSW). While the science units integrate discipline-specific curriculum and pedagogy studies in a sequential way, the number and focus of the units differ across campuses. In Fremantle, WA, the undergraduate degrees—a Bachelor of Education (Early Childhood and Care 0-8 years) and a Bachelor of Education (Elementary)—have two science units offered across the four years of study. Preservice teachers complete 32 weeks of structured practical experience and may have the opportunity to teach and observe science. The graduate entry degree—Master of Teaching (Elementary)—has one science unit offered in the two-year program and the students complete 20 weeks of practical experience.

At the Sydney campus, NSW, students in the Bachelor of Education (Birth to 12 years), Bachelor of Elementary Education, and Bachelor of Elementary Education (Religious Education) complete three science units within their degrees. Differing to the Fremantle campus, the Sydney degrees need to not only meet AITSL (for elementary and secondary education) and ACECQA (Australian Children's Education and Care Quality Authority—for

early childhood education) requirements for initial teacher education, but also need to meet the requirements of the state accreditation body, the NSW Board of Studies, Teaching and Education Standards. NSW has historically focused on teaching Science and Technology as one learning area. Implementation of the Australian Curriculum for Science has required changing and combining the science course syllabuses and subsequently, the state-specific curriculum content needs to be included in the science units within teacher education degrees. Preservice teachers at the Sydney campus complete 31 weeks of structured practical experience.

Because there are no national requirements for teaching science during early childhood or elementary education students' practical experiences, there is a chance that some early childhood and elementary preservice teachers will not be involved in observing or teaching science whilst engaged in their practical experience (Mulholland & Wallace, 2003; Palmer, 2006) which could impact on any teaching of science upon graduation.

Early Career Science Teacher Induction and Registration

Upon graduation from accredited teacher education programs, graduate teachers are eligible to apply for a provisional teacher registration under the assumption that they have achieved the professional standards for teachers at Graduate career stage. Early career teachers are required to move from provisional to full registration in the first few years of their teaching career by demonstrating their achievement of the national professional standards for Proficient career stage (AITSL, 2014). Increasingly, educators acknowledge the importance of in-service professional development in improving the teacher quality (Koch & Appleton, 2007; Sachs & Groundwater Smith, 1999). Various school-based induction programs offer further learning opportunities beyond the initial teacher education program so that beginning teachers can extend their professional knowledge and build stronger professional identity and networks. After investigating the effects of one-to-one mentoring of elementary teachers,

Koch and Appleton (2007) concluded that mentoring does help early career teachers to build better science content and pedagogical knowledge and attitudes towards more constructivist-oriented pedagogy.

Such induction programs are valued not only for early career teachers' professional development but are recognized as a support system to reduce the attrition rate of beginning teachers. In Australia, about 25-45% of all newly recruited teachers resign or 'burn out' in their first three to five years of teaching (Burke, Schuck, Aubusson, Buchanan, Louviere, & Prescott, 2013). In rural and disadvantaged areas and for mathematics and science disciplines, where low numbers of graduate teachers are entering to teach, this issue of teacher attrition is even more apparent and critical because a high teacher attrition rate further hampers the number of teachers entering and remaining in this area of teaching (Ewing & Manuel, 2005; Ormond, 2011). McKenzie, Rowley, Weldon and Murphy (2011) note, in their report called *The Staff in Australia's Schools*, that a higher proportion of early career teachers intend to leave teaching permanently prior to retirement than do teachers as a whole.

When new teachers commence their careers following graduation, the uncertainty faced is more extreme than in any other profession, because the new teacher assumes "full pedagogical and legal responsibility as soon as they enter the school. No other profession has such high expectations of its newest members. This heightens the pressure felt by new teachers and demands special consideration" (Tynjälä & Heikkinen, 2011, recited from Hay Group Report, 2014, p. 8). Nevertheless, researchers (e.g., Ingvarson & Kleinhenz, 2003) have found that the attrition rates for young teachers can be significantly reduced by the development of quality structured induction and mentoring programs. There are specific practices that can benefit beginning teachers' professional growth and are also highly rated by the early career teachers themselves, including having a designated mentor, making

observations of experienced teacher during their classes, and engaging in an orientation program designed for new teachers (McKenzie et al., 2011).

The Hay Group (2014) noted that Australia has been ranked "ahead of the curve in the proliferation of induction programs (for early career teachers) in Australian schools" (p. 23). It is reported that "over 90% of new teachers undertake some form of formal induction" which is above the international average of 75% reported in the Teaching and Learning International Survey conducted in 2008 (Hay Group, 2014).

As an example of the kind of system-wide early career teacher programs conducted in Australia, the Catholic Education Office of Western Australia[3] (CEOWA) negotiated with the teachers' union and agreed to a graduate teacher learning program together with a reduced workload in the first two years of teaching. The program was piloted in 2013 and is being implemented state-wide during 2014 and 2015. Funding for the program is a three-way responsibility, with a third each from the CEOWA, the early career teacher's school and the teachers themselves through participation in school holiday periods. In addition, exploration of ways to reduce teacher workloads is occurring, with some schools identifying ways to achieve this through reduced duties or classes.

The CEOWA's Early Career Teachers Program targets graduate teachers employed in Catholic schools to support their transition into the teaching profession. The basis of this program is to invest in early career teachers by building their professional capacity and resilience in the first years of teaching. During this program, participants are mentored to reflect on areas of effectiveness and potential development and become familiar with the Proficient level of the Professional Standards for Teachers to move towards full teacher registration status. In order to encourage participants to apply newly-acquired knowledge in

[3] In Australia, government (public) and non-government (private) schools are two major education sectors. Non-government schools consist of Catholic and Independent schools, most of which have a religious affiliation.

the context of their school, they are shown how to implement classroom-based learning tasks. Working effectively alongside their colleagues is an essential aspect of being a new teacher in a school and the program is designed to cultivate an inquiry mind-set where graduate teachers are responsive and build on their successes. To address the concerns of early resignations from teaching, the program fosters an outlook of lifelong learning with a longer term consideration of future career development.

Other school systems throughout Australia are implementing similar beginning teacher induction programs with dedicated support programs and additional teacher development time through a reduction of class teaching hours and limited duties. The programs offered to early career teachers in all states and territories of Australia are surveyed and described in a recent report called, *Induction of Beginning Teachers: A Scan of Current Practice in Australia* (AITSL, 2014).

Discussion – Key Issues Influencing the Future

Implementation of the National Curriculum: For or Against Elementary Science Teacher Education?

In elementary schools in Australia, science continues to be one of the least taught learning areas, with less than 5% of the total teaching time dedicated to it, equivalent to approximately one hour per week (Angus, Olney, & Ainley, 2007; Office of Chief Scientist, 2012). Especially beginning elementary teachers are hesitant to teach science even when they successful completed science teaching methods in their initial teacher education programs (Appleton & Kindt, 2002). Australian elementary teachers have identified issues such as perceived low priority of science in the school curriculum, difficulty locating adequate science teaching resources, a lack of the time to prepare and teach science, and insufficient pedagogical content knowledge and confidence in teaching science, which impact upon the quality of their science teaching (Appleton, 2003; Rennie, Goodrum, & Hackling, 2001).

In the Australian Curriculum in 2010, science is included as one of the four learning areas, alongside English, Mathematics and History (ACARA, 2013). The inclusion will certainly influence science teacher education in Australia. The national science curriculum revolves around three key strands: science as a human endeavor, science inquiry skills, and science understanding, and includes biological sciences, chemical sciences, physical sciences, and earth and space sciences (National Curriculum Board, 2009). The Australian Curriculum: Science is currently being implemented in various capacities across states and territories in Australia. Complementary to the Australian Curriculum is Australia's first national framework to guide early childhood curriculum from birth to age five, *Belonging, Being and Becoming: The Early Years Learning Framework* (Australian Government Department of Education, and Workplace Relations, 2009). In this document, early childhood educators are encouraged to incorporate scientific language, content and processes within the early years curriculum, developed through holistic play-based learning experiences and intentional teaching (Nolan, 2012).

This explicit inclusion of science in the national curriculum may imply the demands for modifying initial teacher education programs to educate more science specialists for elementary schools. Considering the high competition for elementary school teaching jobs in metropolitan areas and the potential demand for elementary science specialists, initial teacher education program providers may see strengthening elementary science specialist programs as a way to attract and educate prospective preservice teachers. As an attempt to assist elementary preservice teachers in teaching science and meeting the Graduate standards, various science teaching and learning materials, such as *Primary Connections*, have been widely introduced in initial teacher education programs (Skamp, 2012). The development of the *Primary Connections* project was an initiative of the Australian Academy of Science (Hackling, 2006). *Primary Connections*, based on the 5Es inquiry approach (Bybee, 1997)

and aimed at all elementary school years, is a professional learning program with supporting curriculum resources, which are now linked to the key strands of the national science curriculum. According to the Australian Academy of Science (2011), 56% of elementary schools in Australia are using the materials in some capacity. Schools that have implemented *Primary Connections* have reported a more significant focus on science within the elementary school curriculum (Hackling & Prain, 2005; Skamp, 2012).

However, the inclusion of science in the national curriculum also implies that science may be included in the yearly national testing as well. Currently, the yearly National Assessment Program--Literacy and Numeracy (NAPLAN) includes reading, writing, and numeracy for Years 3, 5, 7, and 9. Scientific literacy is assessed every three years for Year 6 students only. Some science educators fear that if science is included in the yearly national test like literacy and numeracy, it may prevent elementary teachers from teaching science as an inquiry and integrating science into interdisciplinary activities.

Effectiveness of Initial Teacher Education Programs: The Grounds for Teacher Education Reform?

As mentioned earlier, the media and the politicians are calling for reforms in teacher education programs (TEMAG, 2014). When considering ways to improve the quality of initial teacher education, the perception of graduates on the effectiveness of their initial teacher education programs is a natural place to start. McKenzie, Rowley, Weldon, and Murphy (2011) conducted a nation-wide survey of the effectiveness of initial teacher education programs involving teachers (4,599 elementary and 10,876 secondary) and principals (741 elementary and 838 secondary). For the categories of developing and teaching a unit of lessons, reflecting on teaching practice, teaching the subject matter, and working effectively with other teachers, early career teachers and principals alike found that the initial teacher education programs were helpful or very helpful (with 66 to 79% agreement). On the

other hand, they perceived that their teacher education programs were not very beneficial in terms of teaching students from different cultural backgrounds, managing classroom activities, or working effectively with parents or guardians (with 23 to 34 % disagreement). However, these difficulties involving human interactions are not limited to early career teachers. Education literature indicates that experienced teachers often have difficulty truly understanding students' backgrounds and catering their lessons for the diverse student population (Bryan & Atwater, 2002; Gallagher, 2007; NSW Department of Education, 2011; Tan & Kim, 2012; Tobin, 2002), and communicating with parents effectively (Graham-Clay, 2005).

In public discussion of the reform of initial teacher education programs, educators' perceptions of the teacher education programs do not take the center stage but the low entry standards for teacher education programs do. Currently, initial teacher education providers are criticized for giving admissions to students without university entrance test scores (ATAR: Australian Tertiary Admission Rank) or with comparatively low scores. According to a recent Australian newspaper article, science and engineering majors tend to have top performing students—more than 41% of its students have scores of 90 percentiles or over of the year cohort—while education majors consist of a minimal number of high achievers (5.6%) and have the largest proportion of low achievers (less than 50 percentiles) compared to any other majors (Ferrari & Rushton, 2014). If teachers themselves did not do well in school learning, how will they be able to inspire students to learn and excel in the subject they are teaching (Ferrari, 2014)? Also, if a teaching career is perceived as for low-achieving high school graduates or as a waste of academic talent, why would best and smartest students want to choose it (Hiatt, 2014)?

Defending the intake of low achieving students into teacher education programs, some teacher educators openly claim that the high school academic performances of the applicants

do not alone determine the suitability of preservice teachers (Craven, 2014). Teacher education programs adopt other measures to screen applicants for their teacher education programs, such as aptitude tests, and help them improve on their teacher qualities (Hattie & Bowles, 2013).

However, it does not stop the public and politicians from openly blaming the teacher education programs' low entry standards for the 'failing' of school education in boosting students' academic achievement. Inservice teachers and school leaders are also concerned about the declining image of teachers in society, and they would like to see stricter measures implemented in initial teacher education programs and certification procedures (Australian Education Union, 2014b). AITSL (2011a), with the support of the federal Minister of Education and the teacher union, has argued that for admission to initial teacher education programs students should demonstrate their intellectual capacities to be the top 30% of the population based on their Year 12 university entrance scores. At a state level, the NSW education minister promised to enforce a policy to raise the entry standards (minimum university entry scores in three subject areas including English) for initial teacher education programs and to mandate teacher education students to take literacy and numeracy tests and achieve minimum scores before graduating from the teacher education programs (NSW Department of Education, 2013a). AITSL is currently developing a national test to measure the applicants' literacy and numeracy ability and this is due to be implemented in 2015.

However, there is a gap between the desired applicants to teacher education programs and the status quo. A considerable number of current preservice teachers have been entering the initial teacher education programs without meeting the top 30% criteria (AITSL, 2013b; Productivity Commission, 2012). More realistically though, one major problem of limiting the number of eligible applicants for teacher education programs is that many Australian schools are already experiencing a lack of qualified teachers for mathematics and science.

Especially for small schools in remote areas, science is being taught by 'out-of-field' teachers who are currently teaching science even though they are not qualified to teach science (Productivity Commission, 2012).

The extent of out-of-field teachers and the qualifications of science teachers have been extensively discussed in a report prepared for the Australian Council of Deans of Science. *Who's Teaching Science?* (Harris, Jensz, & Bladwin, 2005) which shows the extent to which Australian science teachers are educated to teach the subjects in terms of their qualifications in science. From a survey of 1,200 science teachers and 266 schools nation-wide, Harris et al. found that over two out of five physics teachers did not have a physics major and one out of four chemistry teachers did not have a chemistry major, even for senior secondary school (Years 11-12). For those teaching only junior secondary school sciences (Years 7-8) but no other years, the lack of science qualification was even more obvious because teachers with stronger science backgrounds are usually assigned for upper year science classes. More than one in five science teachers did not take any science courses from university and 13% took only first year science courses. While the heads of school science departments favored a science teacher with strong science backgrounds, preferably with an undergraduate science degree (B.Sc.) in the subject area, many school principals (around 73% nationwide) expressed difficulty finding good qualified science teachers, particularly in physics (41%) and chemistry (31%). Given that this situation is not likely to change quickly, Hobbs (2013) has argued for more research on out-of-field teaching in order to provide "insight for policy makers, school leaders and teacher educators into the conditions required for such teaching to be considered learning opportunities" (p. 271).

Many Australian government and consulting bodies (AITSL, 2013b; Office of the Chief Scientist, 2013; Productivity Commission, 2012) recognize the shortage of qualified, experienced science teachers in remote, low SES areas. They do recommend implementing

incentives to encourage high-performing students to enroll in initial teacher education programs for science disciplines and to stay in such schools, but it is yet unclear what kinds of incentives can be implemented and how effective such measures are going to be. One of the alternative ways to recruit 'high-ability' graduates from other fields and fast-track them to teach in hard-to-staff regional and metropolitan areas was initiated in 2010. The Teach for Australia program is similar to non-traditional teacher education programs in the USA (Teach for America) and the UK (Teach First), and over one third of successful applicants are in Science, Technology, Engineering and Mathematics (STEM) fields (Weldon, McKenzie, Kleinhenz, & Reid, 2013). The program enrolls a small number of career changers, called Associates, through a highly comprehensive screening process (selecting 40 out of 750 applicants each year), provides an intensive six week teacher education induction program, assigns them into socio-economically disadvantaged schools with 80% employment appointment while they complete a formal postgraduate teacher qualification degree with two more intensive education programs during school breaks and the regular support from school-based mentors and university-based advisors for two years.

A series of evaluation studies of the program presented evidence of both productive and some limiting aspects (Scott et al., 2010; Weldon et al., 2012, 2013). Despite their initial reservations, the participating school principals and teacher colleagues of the Associates state that they have shown enthusiasm and commitment towards their teaching and adjusted to school settings better than the traditional beginning teachers. All participating schools want to continue participating in the program. Two territories and one state are currently taking part in the program and one more state plans to join the program (Dodd, 2014). However, the Australian Education Union (2014a) opposes the program because it gives a false impression that six-week initial training is sufficient to teach in difficult classrooms and accuses the program of short-changing students who deserve qualified and experienced teachers. Some

commentators in Australian newspapers express criticism of the program in terms of the cost effectiveness and the drop-out rates (Wilson, 2014).

The Teacher Education Model: Teaching as a Craft to Master or as an Applied Social Science to Participate and Reflect?

In recent debates and reviews of teacher education reforms, one aspect of actual conduct of teacher preparation programs has received more attention—practice-readiness. The tension between practice and theory in teacher education is not new, nor limited to Australian teacher education (Korthagen, Loughran, & Russell, 2006). While preservice teachers often demand ready-made teaching materials and 'practical tips' that work, teacher educators tend to highlight theory-based, reflective teaching practices and take scholarly approaches toward teacher education. This theory/practice tension came into focus when the Minister of Education questioned the relevance or practical value of the current teacher education programs (Pyne, 2014), framing teacher education as a matter of mastering the craft of teaching. Even though many teacher education providers appoint practicing or recently retired teachers (with or without doctoral degrees) to teach discipline-specific teaching methods classes at universities to preservice teachers, the NSW Department of Education (2013b) still reported that "teacher educators are [not] sufficiently in touch with the practices of schools and teachers" (p.12). AITSL (2011a) explicitly prescribes that preservice teachers should be taught by "appropriately qualified staff…[with recent] school teaching experience" (p.15). However, this emphasis appears to overlook or neglect the recent empirical evidence about what qualities of teachers and teacher education are most effective for supporting students and increasing their achievement (Barber & Mourshed, 2007; Hattie, 2009).

It is important for teacher candidates to build the practical knowledge and experience through their teacher education, but the continuous emphasis of practical relevance of current teacher education programs seems to demand that 'expert' school teachers 'train' preservice

teachers to master the craft of teaching, which is a model of teacher education from the past. Historically, Australian teacher education evolved from an 'apprenticeship model' at school to mastering the 'craft of teaching' at teachers' college, then to a more scholarly approach toward education studies at university based on research findings (Aspland, 2006). Accordingly, the demographic of instructors has changed from experienced school teachers to teaching-focused university faculty and now gradually moving into more research-oriented university academics (Murray et al., 2008). The authors of this paper highly value and support the reflective, scholarly approaches to teacher education at both inservice and preservice levels in order to improve and develop teachers' professional identities and practices. Yet, university-based teacher education programs are caught between the preparation of preservice teachers with practical, school-based teaching craft and the institutional expectations towards increasing the scholarly research work as the universities require academic faculty to increase their research productivity (Murray et al., 2008).

Looking into the Future of Teacher Education in Australia

Teacher education in Australia, and science teacher education in particular, faces many challenges—some challenges are new and other challenges are similar to those encountered in previous decades. Like teacher education in the USA, Canada and the UK, the strong political voices in these debates have emphasized international competition, test performance, and teacher accountability, effectively moving (science) teacher education from an academic issue to a 'policy problem' (Mayer et al., 2012, p. 129). Australian education policy makers often claim that they are learning from the Finnish system to build a quality education system and improve on the teacher quality (NSW Department of Education, 2014), as the Finnish education system has been the envy of many Western countries ever since the PISA results were released in early 2000. However, Australian policy makers are introducing more and more accountability measures, limiting the autonomous professionalism both in school

education and teacher education (Sachs, 2001). What is conveniently forgotten in these political debates is that Finnish preservice teachers go through "rigorous, *research-based* teacher education programs" through the combination of undergraduate and Master's programs, and that Finnish teachers have "considerable authority and autonomy, including responsibility for curriculum design and student assessment" (Sahlberg, 2010, p.8). Nevertheless, observing the various angles of public discussions, numerous government reviews, and half-implemented initiatives regarding improving the quality of Australian school education and initial teacher education programs, many science teacher educators are skeptical of any fundamental changes that this round of political initiatives will bring.

We would like to conclude on a more optimist note, albeit at an almost anecdotal level. Despite all the concerns of the findings from the results from PISA and TIMSS, in our work with science teachers, we do not discern any lack of morale with the quality of the current science teacher workforce and a cohort of these teachers participate in workshops and conferences with much enthusiasm. Recent articles published in *Teaching Science* (the journal of the Australian Science Teachers Association) demonstrate much innovation with, for example, developments in early childhood science (Howitt, 2011), improving scientific literacy in diverse classrooms (McCallum & Miller, 2013), and a *Primary Science Specialists Professional Learning Program* in Victoria (Campbell & Chittleborough, 2014).

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