

Quality Initial Teacher Education Review, DESE Submission by the Australasian Science Education Research Association (ASERA)

July 18, 2021

Prepared on behalf of ASERA by:

Associate Professor Linda Hobbs and Professor Russell Tytler, Deakin University, Victoria
Dr Rebecca Cooper, Dr Jared Carpendale, Dr Karen Marangio, Dr Jennifer Mansfield and Dr Connie Cirkony, Monash University, Victoria
Dr Christine Preston, University of Sydney, New South Wales
Associate Professor Rehka Khouli, Curtin University, Western Australia
Dr Carol Aldous, Flinders University, South Australia
Ruth Fentie, University of Technology Sydney, New South Wales
Dr Helen Georgio, University of Wollongong, New South Wales
Angela Gigliotti, Lyn Walker, Australian Capital Territory
Professor Vaille Dawson, University of Western Australia, Western Australia
Dr Reece Mills, Queensland University of Technology, Queensland

Contact: Linda Hobbs l.hobbs@deakin.edu.au

Executive summary

ASERA supports the aims of the Quality Initial Teacher Education (ITE) Review 2021 in opening the discussion around how best to attract and select high-quality candidates into ITE and how best to prepare them to become effective teachers.

Our submission responds to Question 3 of the inquiry: Does the supply of teachers entering the workforce match areas of need?

Challenge 1. Primary science PSTs are excited during their ITE course but then often struggle to see quality examples of science education in schools on placement and often get little opportunity to implement what they have seen in their ITE. A solution is school-based approaches to science teacher education and more time in ITE courses, both of which might allow for authentic teaching opportunities.

Challenge 2. There is a disconnect between the science degree, science education preparation, and employment. This needs solutions that include science content units that are more closely aligned to the curriculum, closer connections between education and science faculties, and building resilience in the system for graduate teachers by creating greater links between schools and university.

Challenge 3. Teacher supply is not meeting the demand in schools, either because of an inadequate number of teachers recruited into teaching or because teachers are inadequately distributed. Incentives are needed for: recruiting quality graduates into science teaching; recruiting from schools; and recruiting career changers.

Challenge 4. The threat of online delivery to quality science ITE. Careful consideration needs to be given about the efficacy of delivering science education methods units online.

Challenge 5. Preparing teachers for the realities of teaching OOF and pathways to re-specialise. It is important to consider: preparing teachers for the realities of OOF teaching during ITE by attending to out-of-field during ITE.

ASERA response

The Australasian Science Education Research Association (ASERA) is a community of science education researchers dedicated to enhancing teaching and learning in science and teacher education, across all contexts and all levels of education. It is committed to evidence-based research across a variety of methodologies. ASERA members have significant links and significant standing in the international Science Education Research community. Its journal, 'Research in Science Education' is a top tier journal, contributing to a global discussion on the teaching and learning of science.

ASERA plays an important role in building and interpreting a strong evidence base for teaching and learning in science. With strengthening calls for evidence-based practice in teacher education, in curricular design and in classroom practices, the operation of vibrant discipline-based research communities informing teacher education has become particularly important.

Our submission responds to Question 3 of the inquiry: Does the supply of teachers entering the workforce match areas of need?

The submission identifies a number of challenges associated with science education and presents some solutions for consideration by the review. STEM education is referred to in the discussion paper, but it is important to note that STEM is not a subject within the Australian Curriculum and that the issues facing the different STEM-related subjects and disciplines vary. Therefore this submission will refer to science unless otherwise stated.

Challenge 1. Primary science PSTs are excited during their ITE course but then often struggle to see quality examples of science education in schools on

placement and often get little opportunity to implement what they have seen in their ITE.

Primary teachers undertake a generalist primary education degree, which prepares them for teaching all subject areas. An ongoing concern is that primary science is rarely observed by pre-service teachers (PSTs) while on placement due to the small proportion of time devoted to science teaching by classroom teachers. A more recent trend is for primary science to be delivered as separate 'science' classes taught by a 'science specialist' (often a generalist teacher with a special interest in science). Observing or teaching these classes may not be part of a PSTs' placement opportunities. An added complexity is that a recent trend towards STEM is displacing science programs focused on investigations and science content with STEM programs that may be interdisciplinary project-based learning or geared more towards design and digital technologies rather than focusing on science.

Solution 1.

School-based approaches to primary science education (where PSTs engage with children in schools) have proven successful in providing PSTs with an opportunity to gain authentic and practical experience of planning, implementing and evaluating a science learning sequence in schools under the guidance of their science education lecturers (Hobbs, Campbell & Jones, 2018). These professional learning experiences can operate as a part of science method units or may be integrated into the formal practicum. These approaches have been shown to raise students' confidence to teach some areas of science during their teaching degree (Herbert & Hobbs, 2018). However, graduate teachers can struggle to implement science in their own classrooms once graduated due to limited opportunities due to the lack of an established culture of effective science teaching, or because of a lack of science resourcing in schools. Effective ITE strategies, therefore, need to operate in parallel with significant commitment to in-service teacher education programs in science.

Solution 2.

Raising the profile of science education within ITE is needed to ensure that adequate time is devoted to science content and pedagogy, particularly in primary-focus courses. This could occur through mandating more hours devoted to teaching science, which would provide the scope for modelling of practice by teacher educators and/or peers through micro-teaching.

Challenge 2. There is a disconnect between the science degree, science education preparation, and employment.

ASERA members observe that PSTs have concerns that there is often not enough science taught as part of the primary education degree, and that the science content units are often disconnected or unrelated to the science that they will be expected to teach. For primary education PSTs electing to undertake a science specialisation, there is a lack of consistency across courses as to what a science specialisation means in terms of content and pedagogy (see for example Mills, Burke & Siostrom, 2020; Bourke, Mills, & Siostrom, 2020).

At the secondary school level, the typical trajectory into teaching is a degree in a particular science discipline completed before or concurrently with an education degree. Science teachers are therefore specialised in a refined set of knowledge, yet they are required to teach the full range of science content as specified in the Science Curriculum. There is a need to address this lack of intersection between discipline-based knowledge and what is required in the curriculum.

Solution 1.

For primary education degrees, the science content units need to be closely aligned to preparing PST for science content and processes that are aligned to the *Australian Curriculum: Science* and relevant for primary schools.

Solution 2.

There is a need for a concerted effort to make clearer connections between the science taught in a science degree and or as part of education courses. Closer relationships between science and education faculties are needed.

Challenge 3. Teacher supply is not meeting the demand in schools, either because of an inadequate number of teachers recruited into teaching or because teachers are inadequately distributed.

Recruiting more science and maths teachers is an important policy response, given that the current teachers in the system are not meeting the demand in certain areas, particularly in rural areas (Weldon, 2016). Inadequate teacher supply begins with low attraction of people to STEM-related degrees at universities, which then translates into an inadequate supply of science and mathematics teachers. The current demand driven approach to teacher recruitment and school appointment means that teachers have control over where they apply for jobs.

Therefore, incentives are needed to attract teachers to appointments in hard to staff schools. A suite of initiatives A-C below are needed to recruit high quality people into teaching degrees and then distribute them equitably across the education system.

3A. Recruiting quality graduates into science teaching

A barrier to recruiting teachers, especially from the sciences and maths, is the continued decline in the number of university graduates in those disciplines. For example, the number of maths graduates has fallen 40% since 2003 (AMSI, 2017). Attracting more people to study science and maths at university should, therefore, be a priority. A targeted response is needed to recruit the science teachers that are in short supply. As indicated in the discussion paper, this includes science teachers with specialisations in physics and chemistry in particular. Many physics teachers have an engineering background, graduates of science and engineering are needed.

A key barrier to graduate recruitment is the work conditions and lower remuneration believed to be associated with a teaching career, compared to a career in science or engineering (Office of the Chief Scientist, 2016, 2020). Also, the perceived low status of the profession needs to be addressed at a discursive level in the way that teaching is spoken about, especially in the media. Based on census data (Office of the Chief Scientist, 2020), people with a STEM qualification at the university level had a higher proportion (34%) of their income in the highest bracket of \$104 000 or above compared to non-STEM qualifications (24%).

It should be noted that these are the most competitive and insecure fields of work, so can result in less employment stability. This is illustrated by the finding that the employment status for STEM graduates is lower than for non-STEM graduates. In 2016, the Office of the Chief Scientist reported that the employment status of all STEM graduates was 81% employed (comparable to non-STEM areas at 80%), but that physics and chemistry graduates were the least employed (70%). The 2020 report shows similar levels for these STEM areas, although earth science has had the greatest decrease in demand (from 85% employed in 2016 to 76% employed in 2020), potentially because of the reduced demand in the mining sector. This means that 20% or more STEM-related graduates are unemployed. While it may be tempting to direct these unemployed graduates into teaching, whether they are suited to teaching is another question.

Solution 1.

Closer working relationships between education and science/maths/IT faculties may increase the recruitment of high-quality science graduates through opportunities such as:

1. offering education units (such as science communication units) to science students as tasters. Already in many education degrees, students take discipline-based units offered by other faculties, usually because of accreditation requirements. The same might be promoted through science/maths/IT faculties
2. students from science/maths/IT faculties can be used as student ambassadors in schools, or through university outreach, to work with school children, assist teacher innovation, and promote their chosen career pathways. These initiatives can attract young people to science, technology, engineering and maths – especially girls (Campbell, Hobbs, Miller, Ragab, Speldewinde, van Driel, 2020) – as well as give tertiary students with an interest in science and mathematics a taste of working with young people.

Solution 2.

Fast tracking teacher education qualifications for high quality graduates is not a solution to producing high quality teachers. It would be better to provide incentives to provide rich learning experiences during the initial teacher education degree rather than reducing the teacher preparation depth and time needed to produce confident and profession ready teachers.

Solution 3.

Other measures for making a teaching degree more attractive can include: reduction or waiving of tuition costs for certain maths/science teacher graduates; and flexible ITE course structure and delivery to enable life-work balance, especially for adult learners returning to study.

3B. Recruiting from schools

Careers education plays an important role in assisting students with career choices. Careers awareness begins in primary school and intensifies as young people enter secondary school and then begin to choose subjects for the senior years. Universities could work more closely with schools to recruit students into teaching maths and science.

This has worked in some parts of the world (for example Sleeter, 2001) for recruiting teachers suitable for multicultural schools.

Further, this strategy has been successful especially for recruiting groups within society that might not normally consider teaching as a career (Petchauer & Mawhinney, 2017). Specific institutions or programs could be tailored to the needs of certain populations. For example, Deakin University's National Indigenous Knowledges Education Research Innovation (NIKERI) Institute enables Aboriginal and Torres Strait Islander Australians flexible access to higher education degrees in an environment with shared cultural values and belief systems.

Solution 1.

Connecting teachers with science and engineering practitioners (such as through the STEM professionals in Schools program by CSIRO) or tertiary students could potentially increase the opportunities for mentoring aspirational young people into STEM careers, and into science teaching. Careers education that includes secondary teaching as a suitable option for students can include formal careers education, greater promotion of teaching by universities at careers forums for school-aged students, as well as stronger promotion of the benefits of a teaching career by science teachers. Parent-focused careers education is an area of great need (Campbell, et al, 2020) due to the strong influence of parents on their children's future career choices.

3C. Recruiting career changers

Career changers who have industry/science experience offer enormous benefits for schools due to the currency of applied knowledge, and experience of life outside of education. For example, those coming to initial teacher education with high quality skills, knowledge and a successful previous career can contribute greatly to the teaching profession through their professional expertise and leadership capacity. Unfortunately, like discipline specific science graduates their breadth of knowledge in all areas of school science may be lacking or not current. They need particular support and mentoring as they transition often from high status occupations to the lower status feminised occupation of teaching.

Incentivisation is particularly important for career changers given that they have often left higher paying careers to enter teaching. Career changers have different needs to the typical science graduate as they often have established family and financial commitments that place greater pressure on them and their families when there is a reduction in family income. Financial incentives and assured ongoing stable positions are more likely to be more attractive. The typically more mobile science graduate who enters a teaching degree may be better served by more immediate incentives, such as bursaries to cover textbooks, fee support, reduced HECS recovery, and scholarships for a global experience program

offered as part of an education course. Most states and territories have these types of incentives, but they are often designed to attract teachers to hard to staff schools.

Anecdotal evidence suggests that career changers, such as successful engineers who decide to go into teaching, can be challenged by the financial burden of undertaking further study to become teachers. While there are some programs offering financial incentives, the ongoing success of these programs is not well documented. Often these incentives are tailored towards having preservice teachers work as paraprofessionals while they are studying and can be focused on numeracy and literacy support for students. Such programs run at a high cost and can see preservice teachers exploited working too many hours in schools and underperforming or neglecting their ITE commitments. A further concern of programs where preservice teachers spend a significant amount of time in schools is with inconsistent mentoring.

Solution 1.

We need to attend to a disconnect between ITE and school employment by building resilience to reduce attrition in the beginning years of teaching. This could be achieved by stronger links between universities and schools support teacher transition into the workforce. Coming out of a high-status profession after a successful career and being able to move into another high-status profession with the opportunity to have another successful career could also be appealing.

Challenge 4. The threat of online delivery to quality science ITE

Recent events have led to a need for online learning to play a more significant role in teacher education. While it can be acknowledged that online/blended programs may well be cost-effective; however, are they producing quality teachers? Preservice teachers who need high levels of support are getting this support online but ASERA members have noticed that sometimes this online support is not progressing preservice teachers' professional development as it should, or in some cases, students are not accessing support as needed. This is particularly a concern when placements are online.

If we want to promote and uplift the status of the teaching profession then are online/blended or even fast-tracked short term programs the answer? We have high standards for our future teachers and high standards in our initial teacher education programs. Meeting these standards and producing high-quality teachers will take time and commitment. Further, having more qualitative ways of representing teacher readiness will be important, but these will also take individualized support and time to work with students to develop in meaningful ways.

Challenge 5. Preparing teachers for the realities of teaching OOF and pathways to re-specialise.

One of the realities for many graduate teachers is having to teach subjects that do not match their background, that is, teach out-of-field. Data shows that graduate teachers are most vulnerable and susceptible to the effects of OOF teaching due to the lack of other teaching skills that might compensate for limited expertise in teaching the OOF subject. For science, the experience of teaching OOF is has

even greater complexity due to the multidisciplinary nature of General Science, which can result in science teachers 'feeling' OOF teaching science disciplines that they did not major or minor in at university, for example, a Biology teacher teaching a Physics unit in General Science in years 7-10.

Shah et al.s' (2020) analysis of the 2015 PISA teacher questionnaire data indicated that in Australia approximately 20% of teachers teaching Mathematics out-of-field taught no other subjects at that time. For Science this was 23.7% and Technology 10.6% (Table 22). More out-of-field than in-field teachers in all subjects were teaching more than two subjects at the time, potentially adding more stress to these teachers' work. This is an indication of the concentration of out-of-field teaching that some teachers undertake.

One question raised by the Discussion Paper is why STEM (science and maths) teachers are not teaching in their in-field areas. A number of observations help to understand this question:

- Timetabling will often prioritise science teachers into their senior science areas, leaving the science in the middle years to be taught by OOF teachers;
- Some teachers request to teach other subject areas; and
- Teachers who excel when teaching the subject OOF, are the most capable teacher in a small school for teaching the subject, or who undertakes professional development or upgrade in the OOF subject may find that they are teaching the OOF subject more than their in-field areas. (Incidentally, this possibility can be a reason that OOF teachers do not undertake PD in the OOF subject.)

A close look at Shah et al's (2020) analysis shows that science and mathematics teachers of 1-5 years of experience were teaching more out-of-field classes than their experienced colleagues: 15.4% in-field and 20.8% out-of-field mathematics teachers, and 18.1% in-field and 22.0% of out-of-field science teachers. This pattern was not evident for technology. Data from Weldon (2016), however, indicated that more than a third of early career teachers (in their first five years of teaching) are teaching out-of-field for some of the time, compared to one quarter of teachers with more than five years' experience.

For graduate teachers, science had the highest proportion of out-of-field teachers compared to in-field teachers (6.1% compared to 3.9% respectively), while technology showed the opposite trend with technology taught less by out-of-field teachers than in-field teachers (0.5% compared to 2.6%). Similarly, Van Overschelde and Piat's (2020) analysis of teachers in Texas, United States, showed that out-of-field teaching was negatively correlated with teaching experience, meaning that teachers teach less out-of-field as they gain more teaching experience.

This tendency to place temporary teachers and less experienced teachers in out-of-field situations suggests a culture of initiation where less experienced teachers have less control over what they teach. This is particularly disturbing since data from the United States (Fitchett et al., 2019) show that out-of-field teaching is a statistically significant predictor of teacher burnout and workplace fatigue. This is compounded further when the students that out-of-field teachers are assigned to teach are more likely to be low-achieving students. Hill and Dalton (2013) found that low-achieving year 9 students were more likely to be allocated an out-of-field teacher than high achieving students.

Accreditation of ITE programs often leads to siloed methods training that is linked to specialisation requirements for teachers. While this is necessary to ensure that methods training align with disciplinary training, it also means that PSTs are typically exposed to a limited set of subject-related content, pedagogy and curriculum, thus limiting opportunities for preparing teachers for the realities of OOF teaching. While it is not possible to prepare secondary teachers to teach all subjects, it is important that PSTs have opportunities to at least be aware of the realities of OOF teaching and be armed with strategies for coping and managing the challenges when they do step into an OOF teacher role.

Solution 1.

A study examining ITE courses from the perspective of teacher educators and PSTs identified different aims associated with activities that supported the development of teacher-ready, adaptable teachers (Campbell et al 2019):

- *Awareness raising* activities make students aware of the realities of teaching, including the likelihood of having to teach out-of-field and the need to be adaptable, how out-of-field teaching might influence classroom practice, and how it can impact on teachers securing a position.
- *Capacity building* activities build students' thinking skills, relational skills and general teaching skills; encourages them to make meaningful connections between ideas from different subject areas and pedagogy, and assists in creating links between their background with whatever they are teaching; and builds their capacity to reflect, learn and innovate, including being open-minded, seeking and inquiring.
- Activities that aim to *shape identities* focus on moving teachers towards orientations that sympathise with the following: coping with uncertainty and uncertainty as a disposition, vulnerability is seen as a strength, the discipline doesn't define them, mastery orientation based on the belief that they can do something through effort, believe they can make a difference.

Some interesting trends in the data showed that science teacher educators raised awareness of OOF teaching more so than the maths teacher educators. However, exposure to the reality of teaching OOF was usually indirect rather than through explicit discussion of skills and attitudes needed. The study also showed that an ITE program is likely to be most effective in preparing teachers for OOF teaching if they incorporate activities that have the three aims (identity, awareness and capacity), and there are a suite of coordinated activities that are embedded within the core units as well as the method units. Activities that give them a mindset that supports developing adaptive expertise, such as multi-disciplinary experience in core units.

Solution 2.

PSTs should be made aware of possible pathways for gaining qualifications in additional specialisations, and the value that this might have for themselves, their students, their school and the profession. It is important to clarify the status of courses designed for upskilling qualified teachers, how they interact with initial teacher education courses, and with discipline-based qualifications. There is, however, a lack of pathways for non-science teachers to upskill to teach science, no mechanism for formal recognition of this if teachers do commit upskilling (in many states), and no incentives within the profession to do this except improved teaching, often at the discretion of principals.

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