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A Systematic Review of the Research on the Knowledge and Skills of Australian Preservice Teachers

Jennifer Stephenson
Macquarie University, jennifer.stephenson@mq.edu.au

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Jennifer Stephenson
Macquarie University

Abstract: Since knowledge and skills related to curriculum content and pedagogy are crucial for teachers, it is of interest to explore the research relating to what preservice teachers know and can do. Refereed journal articles published between 2005 and 2015 that reported on the assessment of the knowledge or skills of Australian preservice teachers are reviewed. Data were extracted from 52 articles relating to the context of the research, participants in the research and the adequacy of the knowledge and skills of preservice teachers. Most authors expressed some concern about the level of knowledge and skills of preservice teachers and where both were reported there was often a discrepancy between perceived and actual knowledge.

Introduction

Australian teacher education may be a "highly scrutinized domain" (Rowan, Mayer, Kline, Kostogriz, & Walker-Gibbs, 2015, p. 274), but the scrutiny appears to have come from enquiries and reports, not from research and systematic reviews of research. Murray, Nuttall, and Mitchell (2008) reported on a survey of the literature on initial teacher education from 1995-2004. They included research published in peer-reviewed journals on teacher preparation and also research on newly qualified teachers. Out of the 215 papers they included, there were 11 papers on subject content knowledge, 19 on general pedagogical knowledge and skills, three on maths pedagogical content knowledge and two on science content knowledge. Since any single paper might address one or more of these areas, it is difficult to determine exactly how many papers overall related to preservice teacher (PST) knowledge and skills. There is also no indication of how many papers reported on formal measures of knowledge and skills. They did report concern about PST knowledge in the areas of maths and science. Content knowledge is important for all teachers, and if preservice primary teachers lack basic knowledge, teacher educators need to be aware of problem areas and education courses need to provide remediation. It appears there have been no relevant reviews since Murray et al. (2008). Recent commentary articles on teacher education research in Australia, Mayer (2014) and White (2016) did not cite any reviews apart from Murray et al..

The most recent in the long line of reports and enquiries into initial teacher education, charged, among other things, with examining how well preservice teachers (PSTs) understand the content they are to teach (Mayer, 2014) made the unsurprising finding that "Beginning teachers need a solid understanding of subject content, pedagogy, and pedagogical content knowledge" (Teacher Education Ministerial Advisory Group, 2014, p.18). This statement reflects one of the more consistent findings of research on factors affecting teacher quality, which is that teachers must have good content knowledge in the

disciplines they teach, have a generic knowledge of effective pedagogies and more specifically, sound pedagogical content knowledge (Centre for Education Statistics and Evaluation, 2014; Coe, Aloisi, Higgins, & Major, 2014; Hattie, 2009; Jensen, Roberts-Hull, Magee, & Ginnivan, 2016).

These three aspects of knowledge for teaching were highlighted by Shulman (1986) in his influential analysis of the kinds of knowledge needed by teachers. Content knowledge relates to knowledge of the content to be taught and pedagogical content knowledge relates to knowing how to present specific content in a way that is comprehensible to students and knowing what is likely to promote or enhance the learning of that content by different students. Pedagogical knowledge, generic knowledge about teaching, is knowledge that applies to general skills and includes areas such as classroom management. Pedagogical content knowledge builds on and interacts with content knowledge and the difference between them may not always be clear-cut (Goulding, Rowland, & Barber, 2002; Jensen et al., 2016). Shulman also categorised knowledge about learners and their characteristics, curriculum knowledge, knowledge of educational contexts such as governance and knowledge of educational ends, philosophy and history. More recently Shulman's categorization has been extended to include technology knowledge (Koehler & Mishra, 2009).

Louden (2008) noted that enquiries into teacher education up to that time had had little impact and many PSTs were reporting they were poorly prepared for teaching. The federal government, through the Council of Australian Governments, began reforms to improve teacher education in 2008 and released the National Professional Standards for Teachers in 2011 (Ingvarsen, 2010; O'Meara, 2011). The Australian Institute for Teaching and School Leadership (AITSL) is now responsible for accrediting both initial teacher education programs and teachers, and the accreditation of initial teacher education programs was strengthened as a result of the Action Now: Classroom Ready Teachers report. The revised standards were implemented from 2016 (AITSL, n.d.).

AITSL requires providers to show that preservice teachers have "demonstrated successful performance against all of the Graduate Teacher Standards" (AITSL, 2015, p.10). Programs to prepare primary teachers must include content, pedagogical knowledge, pedagogical content knowledge and curriculum knowledge in literacy, numeracy and other learning areas. Programs to prepare secondary teachers must provide these categories of knowledge in a specialist area. The graduate standards themselves cover these areas and in addition graduate teachers must have knowledge of students and how they learn (AITSL, 2015). In addition, initial teacher education students must pass a test of literacy and numeracy knowledge before graduation (Australian Council for Education Research [ACER], 2016).

Given the general recognition of the importance of the various kinds of knowledge to be acquired by PSTs and the current policy directions aimed at ensuring PSTs have adequate knowledge of content and pedagogy, it seems that a review of the research published since the Murray et al. (2008) review would be of use. In particular, research studies that have reported on direct assessment of Australian PST knowledge and skills would provide a useful overview of what is known, rather than surmised and would also provide information on actual assessed knowledge rather than PST perceptions of their knowledge. The overarching research question for this review is: What research, published in refereed journals, has been conducted to assess the content knowledge and skills of Australian pre-service teachers being prepared to teach in general education settings between 2005 and 2015? More specific research questions addressed how many studies have investigated PST knowledge through direct assessment, where, when and by whom were the studies carried out, how many participants were included, who they were and how representative were they, what aspects of PST knowledge and skills have been assessed, what are the findings about knowledge and

skills of PSTs, and how do PSTs perceptions of their knowledge and skills relate to their actual knowledge and skills.

Method

A search of the databases Education Research Complete, ERIC and A+ Education was carried out in July 2016. The search terms used included combinations of preservice or pre-service teacher or teachers or teacher education students or preservice or pre-service primary teachers or preservice or pre-service secondary teachers or preservice or pre-service elementary teachers; skills or knowledge; Australia or Australian; and assessment or survey or questionnaire. The search was limited to refereed journal articles published in English between 2005 and 2015.

This search resulted in 1093 hits and 858 unique articles were retained once duplicates were removed. The titles and abstracts of these articles were screened and articles were retained if the participants were Australian preservice teachers being prepared for general education settings and if the article reported a measurement of their knowledge or skills, or if it was unclear if the article met the criteria. After screening, 108 articles were retained. A research assistant screened 20% of the 858 articles against the criteria and inter-rater reliability was 84% for article selection (calculated by dividing agreed articles by the total of agree and disagreed articles and multiplying by 100). For the 15 articles where there was a disagreement, both the author and the assistant examined the full text and agreed that 14 should be excluded, and one article was added.

The full text of the 109 articles retained was obtained, and examined to determine if the articles met the stated criteria and also if the data pertaining to preservice teachers could be separated from the data of any other participants where these were included. There were 33 articles retained at this stage.

An ancestral search of the reference lists of the retained articles was carried out and a further 12 articles meeting the criteria were found. Citations of each article were located through Google scholar and an additional four articles were found. In addition, the list of articles located by the author in an earlier search related to survey-based research carried out with Australian PSTs was reviewed and an additional five articles were located (Stephenson, 2017). An additional study was located incidentally.

Data were extracted from 54 articles, but during the data extraction process two further articles were excluded. Carey, Christie, and Grainger (2015) was excluded because only improvement in knowledge was measured and reported and Dudley and Baxter (2013) was excluded because analysis of knowledge could not be separated from analyses of attitudes and beliefs. Complete data extraction was thus carried out for 52 articles. Where articles addressed other aspects of PST education, the only data extracted were those relating to skills and knowledge and perceptions of skills and knowledge.

The data extracted included:

- The state and university(ies) where the study was carried out
- Sample size and representativeness, gender breakdown of sample, and age information.
- Nature of the teacher education course (early childhood, primary and/or secondary or other and whether undergraduate or post graduate).
- Description of participants.
- Knowledge or skill domain (science, maths, literacy, special needs students, sustainability, global warming/climate change, child protection, self-injury, evidence-

based practices. values education, physical education, equity in education, behavior management, ICT, communication skills).
- Recruitment procedures.
- How the knowledge/skills assessment was carried out, including information about the instrument or task used, details of knowledge assessed, and data analysis procedures.
- Study findings, including if perceptions of knowledge were measured and if so how, actual knowledge compared to perceptions, and factors influencing knowledge and if there were any factors that appeared to impact on PST knowledge.

The nature of the knowledge assessed in each article was classified into one of Shulman's (1986) categories of teacher knowledge, specifically content knowledge (what is to be taught), curriculum knowledge (materials and programs), general pedagogical knowledge, pedagogical content knowledge, knowledge of learners and their characteristics, knowledge of educational contexts and knowledge of educational ends.

Finally, a judgement was made regarding the adequacy of PST knowledge. This drew on the reported results and the author conclusions. Knowledge was judged as "inadequate knowledge" if there was a clear statement to that effect made by the authors or if there was no comment made by the authors, mean scores on the measurement task were less than 80% or less than 80% of the participants met the standard set by the authors. This level is an arbitrary standard, but on the few occasions when authors provided an acceptable standard, that standard was between 70% and 85% correct on assessment tasks (Bain, Lancaster, Zundans, & Parkes, 2009; Goldman & Grimbeek, 2008; Klinger, 2011; Thwaites, 2008). The category of "mixed results" was used if the authors thought a reasonable standard had been met by most participants, or by all participants in some aspects of the topic or if there was a generic recommendation for more education on aspects the topic while acknowledging adequate knowledge in some aspects of the topic. "Adequate knowledge" was used if the authors made a clear, unqualified statement to that effect or if at least 80% of PSTs had adequate knowledge or if the mean score was 80% or more. Where there was a difference between author interpretation and results, author opinion was used.

A research assistant was provided with the criteria for judging the adequacy of PST knowledge and trained with studies not used in final reliability assessment. The author and the assistant then independently ranked the adequacy of knowledge as reported in 11 randomly selected papers (21%). Reliability, calculated as for paper screening, was 81%, which is acceptable.

Results

There were 52 articles that reported on 51 studies that included measures of PST skills or knowledge. Two articles reported on the same study (Geng, 2013 and Geng & Disney, 2013). As Figure 1 shows, there were between two and eight articles published each year, apart from 2007 when no relevant studies were located. For 20 articles, the state(s) involved were not provided. There were three studies where the authors reported that more than one state or territory had been included. Berger, Reupert, and Hasking (2015) included participants from both territories and five states, Beswick and Goos (2012) included participants from all states and the Northern Territory and Goos (2013) included participants from six states/territories. Overall, 15 studies included participants from Queensland, eight included participants from New South Wales, four from Victoria, three from Western Australia and Northern Territory, two from South Australia and Tasmania and one from

Australian Capital Territory. The university(ies) where the studies were carried out were provided infrequently with only 10 studies naming a university.

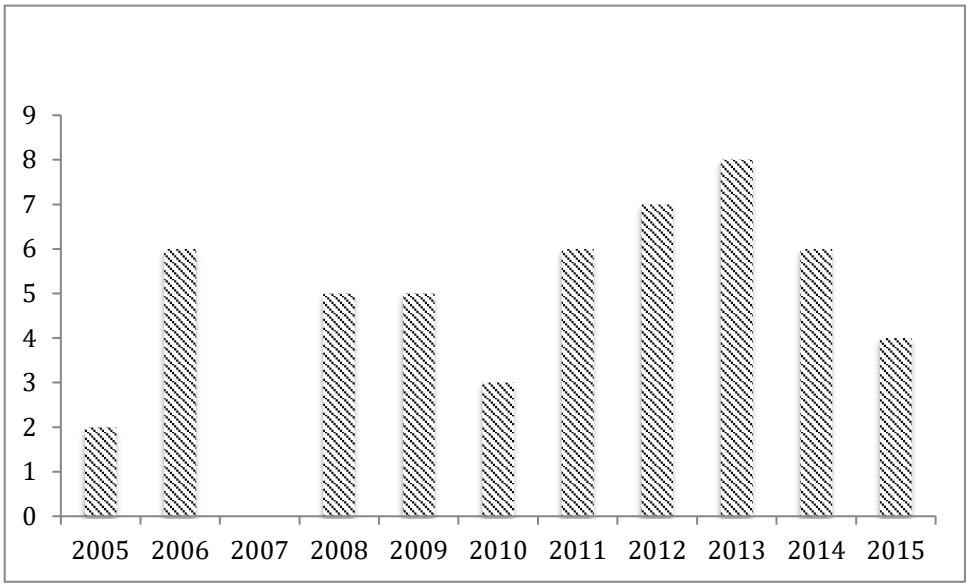

Figure 1: Articles published per year

Participants

Just over half the studies (28) were based on a cohort who had completed a particular unit or units of study or a particular activity, 12 studies were of final year PSTs and eight recruited from whole courses and three from particular year cohorts within a course. The majority of PSTs included in the studies were preparing to be primary school teachers (included in 41 studies) with 14 studies including those preparing to be secondary teachers and 11 those preparing to be early childhood teachers. There were 45 studies including undergraduates and 13 including postgraduates and three where it was not clear if PSTs were under- or postgraduates or a combination of the two. Twenty-three studies provided information about the ages of the participants and 15 about the gender. Recruitment procedures were not described in 28 studies. Students were recruited in a class or lecture for 21 studies (this includes studies where the assessment was a mandatory component or an in-class component), and a few studies used email or a website. Two studies used two methods of recruitment.

Sample sizes in the studies ranged from fewer than 50 to over 400, with 18 studies with 51-100 participants. Information about representativeness (such as return rate of surveys or the proportion of students who volunteered to be involved) was not provided for 34 of the studies. In eight studies the whole of the relevant cohort participated. There was only one study where the return rate was less than 25%, and six studies had return rates over 50%. One study provided details about the university return rate that was 15 out of 48 universities approached (Carter, Stephenson & Hopper, 2014) and one reported that 66 out of 129 subject coordinators across 14 universities agreed to participate (Berger, Reupert & Hasking, 2015).

Knowledge and Skills Assessment

The studies covered 15 topic areas, with most studies in the areas of literacy and numeracy. The 14 literacy studies included 11 that addressed content and three that addressed

pedagogical content, while the 12 numeracy studies included six that addressed content, four that addressed both content and pedagogical content and two that addressed pedagogical content. Other topic areas included child protection (five studies – knowledge about educational context, knowledge about learners, pedagogical content knowledge and pedagogical knowledge), sustainability (5 studies – all content knowledge), and students with special needs (three studies – knowledge about learners and pedagogical knowledge). There were two studies addressing the areas of global warming (content) and science (content and pedagogical content) and one study on each of physical education (pedagogical content), equity (pedagogical knowledge), behavior management (pedagogical knowledge), self-injury (knowledge about learners), evidence-based practice (pedagogical knowledge), values education (content and pedagogical content) and ICT (pedagogical content). One study on communication addressed oral presentation skills. A detailed results table may be obtained from the author.

The most common form of assessment used was a paper survey type exercise under examination conditions (no talking or collaboration) used in 13 studies, 11 studies used a paper survey type exercise but the authors did not state that it was held in examination conditions, or it was completed out of class. Nine studies used an online survey. Survey formats most frequently used open-ended questions (25 studies) and multiple-choice questions (18), with several surveys using more than one kind of question. Four articles did not contain a clear description of how a paper-based survey was administered. A pre-existing survey or assessment was used or adapted in 19 studies (including two which used NAPLAN assessments), and the remaining survey studies used an instrument devised by the authors or others.

Nine studies analysed classwork or a non-examination assessment task, five analysed final examination results, three analysed a formal assessment at the commencement of a course or unit, one used quizzes during a unit, one used an interview and one used observation of PSTs while tutoring. There were three studies that used two forms of assessment. Overall, there were 20 studies that assessed knowledge and skills under exam conditions. Both pre and post assessments were used in six studies where students completed a specific unit of study, one study reported on three assessments during a single unit and one on a series of four assessments. There was only one study that assessed PSTs during actual instruction of school students using an observational checklist.

All articles reported descriptive statistics of some form and fifteen reported some form of qualitative data as well. Statistical analysis such as t-tests, ANOVA, MANOVA, correlations or regression analysis were carried out in 23 articles to explore factors affecting knowledge, to explore relationships between perceived and actual knowledge or to establish differences between pre and post results. Rasch measurement models were used in three studies (Beswick & Goos, 2012; Goos, 2013, Ryan & McCrae, 2006).

Judgements of Adequacy of Knowledge and Skills

Judgements of the adequacy of the knowledge of the sample of PSTs in each article drew on author conclusions for all except six studies where reported results had to be used (Anderson et al., 2012; Cavanagh et al., 2014; Geng, 2013; Prieto et al., 2015; Taylor et al., 2006; Tetley & Jones, 2014). Table 1 (see appendix) shows the adequacy of knowledge for each article, and whether or not the assessment was under examination conditions.

There were 30 (57.7%) articles where the knowledge or skills of participants was judged inadequate. Authors made comments such as: “knowledge base regarding environmental issues was minimal and insight into the social, cultural and economic

complexities of ESD [education for sustainable development], was lacking or quite superficial" (Stir, 2006, p.832); "Many undergraduate students appear to have literacy problems so fundamental that remediation in the late stages of their degree program cannot hope to overcome a lifetime of poor literacy performance" (Moon, 2014, p.128).

There were 12 (23.1%) articles where the results were mixed and author comments included: "The findings presented here suggest that the inclusion of strategies designed to ensure the transference of content knowledge from one course into another supported most of the pre-service teachers … Twenty per cent (N=10) … did not transfer any knowledge about language." (Fenwick et al., 2014 p. 97); "student-teachers can readily identify pedagogies that enable their primary school students to understand, apply, and analyse types of factual, conceptual, and procedural knowledge ... However, our findings show that deeper thinking, as characterised in the suggested south-east quadrant of Anderson and Krathwohl's framework, is seldom exhibited by student-teachers, even those close to graduation" (Goldman & Bradley, 2011, p.489).

There were ten (19.2%) articles where the authors believed the PSTs had adequate knowledge and comments included: "For most of the pre-service teachers involved in this study, a 12-week unit … effectively developed key understandings and teaching practices required to work in contexts where students traditionally do not succeed within schooling" (Fenwick & Cooper, 2013, p.106); "The data from these student teachers suggest that, overall, respondents have basic knowledge about child sexual abuse strategies, comprehend them, and can apply them" (Goldman, 2005, p. 88). Each of the articles where knowledge was judged as adequate assessed students after they had completed a unit or units, an activity or a remedial intervention on the knowledge assessed.

Relationship of Perceptions to Actual Skills and Knowledge

Fifteen studies also assessed PSTs perceptions of or confidence in their knowledge and/or skills (studies that measured perceptions of improved knowledge were not included). These measurements were made by responses to Likert-type items regarding levels of confidence in knowledge or abilities, except in Thwaite (2008) where students responded to true/false items about the level of support they thought they would need. Table 2 summarises the relationships. Some studies looked for correlations or associations between perceived and actual knowledge, and some examined associations between the level of confidence and level of knowledge. Perceived knowledge was less than actual knowledge in only one study, although five studies reported a positive relationship between perceived and actual knowledge.

Perceptions higher than knowledge	Perceptions lower than knowledge	Perceptions about the same	Higher perception related to more knowledge	No association between perception and knowledge
Boon (2011)	Brown (2008)	Goldman & Grimbeek (2008)	Anderson et al. (2012) (Moderate correlation)	Beswick & Goos (2012) (for PCK)
Bostock & Boon (2012)		Harper & Rennie (2009)	Berger et al. (2015)	
Effeney & Davis (2013)		Mahar & Richdale (2008)	Beswick & Goos (2012) (overall knowledge and for MCK)	
Fenwick et al. (2014)		Thwaite (2008) (for 39% of participants)	Geng (2013) and Geng & Disney (2014)	
Meehan & Hammond (2006)			Tetley & Jones (2014) (weak to moderate)	
Thwaite (2008) (for 54% of participants)				

Table 2: Relationships between Perception of Knowledge and Actual Knowledge

Factors Influencing PST Knowledge

Factors that might be related to knowledge were examined in 20 studies (mostly using ANOVA and/or t tests, although some studies used MANOVA or non-parametric methods). The results of those analyses are presented in Table 3 Five studies (Christian, 2014; Mulholland & Ginns, 2008; Norton, 2012; Taylor et al., 2016; Yeigh, 2013) that used pre and posttests, tested the difference and all showed significant improvement at posttest, apart from one measure of MCK in Norton (2012) that was already high at pretest.

Study	Factors
Literacy	
Bostock & Boon (2012)	Differences across year cohorts for all skills except identifying verbs.
Fielding-Barnsley (2010)	No difference between early childhood and primary PSTs or for year of study.
Fielding-Barnsley & Purdie, (2005)	PSTs less knowledgeable than inservice teachers
Geng (2013) and Geng & Disney (2014)	First year UG and PG made more mistakes than yearrs 2-4 UG; PSTs who texted more were more correct, no relationship to age.
Mahar & Richdale (2008)	PSTs less knowledgeable than inservice teachers. No difference between supervised and unsupervised completion.
Tetley & Jones (2014)	No effect for latest practicum in K or Yr 1 class; no effect for reported practicum supervising teacher attitude; no effect for exposure to strategies in class; lower knowledge for those exposed to Reading Recovery and higher knowledge for those exposed to structured commercial phonics programs.
Thwaite (2008)	Highest at pre-test for those with an incomplete degree on entry to education course; no effect of being multi-lingual.
Numeracy	
Beswick & Goos (2012)	For MCK, PG students did better than UG; off-campus students did better than mixed-mode; those with at least Yr 12 maths did better than those with only Yr 10 maths; those with a degree did better than those without.

Goos (2013)	No difference between programs for MCK or PCK; those with higher levels of previous maths study had higher MCK but not PCK. MCK was a predictor of PCK and vice versa.
Norton (2012)	Those with higher levels of prior maths had higher pre and post for both MCK and PCK. High MCK associated with high PCK.
Prieto, et al. (2015)	No effect for gender, masters students did better than UG except on academic literacy.
Child protection	
Goldman (2005)	No effect of gender on level of knowledge
Goldman & Bradley (2011)	No gender or age differences, except some higher levels for older PSTs and those with higher GPAs
Sustainability	
Boon (2011)	No difference between different specialist areas or according to age.
Effeney & Davis (2013)	3rd yrs more knowledgeable than 1st yrs.
Global warming	
Boon (2010)	Those preparing to be science or SOSE teachers were similar to non-specialist teachers
Students with special needs	
Anderson et al. (2012)	No difference between PSTs with and without experience of ADHD
Bain et al. (2009)	Students who learned through co-operative learning did better than those who learned through peer-assisted learning or who studied alone.
Self-injury	
Berger, et al. (2015)	Prior training in self-injury had no effect.
Communication skills	
Cavanagh et al. (2014)	Improvement in communication skills over the course of the unit (measured on four occasions).

Table 3: Factors associated with Knowledge

Discussion

It is surprising that so few studies have directly explored the knowledge of PSTs over the 11 years reviewed. There was an upward trend in the number of studies that peaked in 2013, but the numbers seem to be declining again. The Murray et al. (2008) review found around 35 papers over the ten years of their review and the output of research on teacher education has increased since that time. It is also surprising given the number of reviews of teacher education, the lack of evidence for the impact of teacher education programs (Ingvarsen, Reid, Buckley, Kleinhenz, Masters, & Rowley, 2014; Louden, 2008; Rowan et al., 2015), and the ongoing claims of early career teachers that they were not well prepared (Ingvarsen et al., 2014; Louden & Rohl, 2006).

Studies have been mostly limited to one state and to one institution with only three studies with participants from more than one state. There have been calls for teacher education researchers to move away from these small-scale projects and to begin projects that make comparisons across different programs (Ingvarsen et al., 2007; Louden, 2008), but the published studies are largely small scale and there were no comparisons made across institutions. Only 10 articles named the institution where the study was carried out, and this might suggest a reluctance for program outcomes to be identified with a particular institution and perhaps presages a possible distaste for comparison research.

In keeping with the generally small scale of the studies, sample sizes were modest, with well over half having 200 or fewer participants. The means by which knowledge was assessed was well described in most studies, but it was not always clear whether tasks were

completed in examination conditions or not. One survey (Mahar & Richdale, 2008) found no difference in the results for PSTs who completed the survey in the presence of an investigator and those who did not. Livy at al. (2012) reported that many PSTs who had access to their notes and a textbook during an assessment task were still unable to give correct answers. In one respect, it would be of more concern if inadequate knowledge was apparent when PSTs were free to consult or use any available resources.

Well over half the studies had undergraduate, primary PSTs as participants, with roughly equal numbers of studies including secondary and early childhood PSTs. The representativeness of the samples was generally good where it was reported, but far too many studies did not indicate how representative the sample was and participation rates were not often reported. Similarly, well over half did not provide information on the age or gender of the participants, and although few effects on knowledge were found for these variables when they were investigated, full reporting requires clear sample descriptions. Of more concern is that 29 studies did not clearly describe how participants were recruited. If this information is not provided, readers cannot make judgements about the representativeness of the sample.

There was much more focus on content knowledge than on other categories of teacher knowledge and this probably reflects the fact that it is easier to assess content knowledge than pedagogical content knowledge. Generally content knowledge was assessed through a survey-type instrument or through formal assessment tasks associated with courses or units. Basic skills and knowledge in literacy and numeracy were the most common content areas to be addressed. Some content areas such as health, geography (beyond global warning and sustainability), history and the arts were either addressed in only one study, or not addressed at all. Similarly, some areas of pedagogical knowledge such as assessment, reporting, interpretation of large-scale assessments and evaluation were not addressed. In addition, there was only one study where results were based on actual observation of PSTs while teaching students (Dawkins et al., 2009).

Judgements made about the adequacy of the results relied as far as possible on author interpretation. The knowledge of PSTs was judged inadequate in 57.7% of the articles and there were mixed results in 23.1% of articles. Only one study of maths and only one of the studies of literacy made a finding of adequate knowledge. The ten studies where the authors judged knowledge to be adequate were all based on assessment of knowledge gained during a particular unit, activity or remedial course.

The results of some of the studies reported here would certainly provide ammunition for those who criticise the quality of PST preparation. For example, many PSTs had very poor basic literacy skills (Moon, 2014), lacked knowledge of the basic content knowledge required for teaching of reading (Fielding-Barnsley, 2010) and lacked basic numeracy knowledge (White et al., 2006). Some of the specific areas assessed also indicate a lack of ability to think critically and a disturbing lack of comprehension. For example, Moon reported that some PSTs in the third or fourth years of their courses were unable to define "pedagogy" and Livy and Vale (2011) reported that over 30% of the PSTs they assessed thought that 6 cm on a map of a small area of Victoria would be equivalent to more than 15,000,000 km and were "not able to think about the reasonableness of their answer" (p. 38). There were no studies of more sophisticated areas of mathematics, such as the critical statistics literacy skills needed by teachers to make sense of data such as NAPLAN results (Chick & Pierce, 2013). The single study addressing PST knowledge of evidence-based practices (Carter et al., 2015) found that PSTs tended to believe that all practices presented to them had a sound research base, regardless of the actual evidence base.

At the same time, there is evidence that when the content of units is appropriate, or when remediation is provided, PSTs can acquire the necessary content and skills. See, for example, Yeigh (2013) who reported changes in PST knowledge of and attitudes to the

factors influencing student behavior and effective intervention and Thwaite (2008) who reported on a remedial program addressing text writing, including spelling and grammar. These findings reflect international research that shows completion of units with specific relevant content can improve PST content knowledge (Jensen et al., 2016). The research on pedagogical content knowledge is less clear, but some of the studies here indicate that practice teaching, analysis of actual teaching, and practice in writing lesson plans and program sequences (Beswick & Muir, 2013; Dawkins et al, 2009; Fenwick et al., 2014; Lloyd & Mukerjee, 2012) may help pedagogical skills and knowledge. The study by Cavanagh et al. (2014), even though the skills were judged inadequate based on the results, showed that PSTs can improve practical and essential communication skills when provided with multiple opportunities for practice with feedback.

Fifteen of the studies included some measure of PST perceptions of or confidence in their knowledge or skills, but only one reported that PSTs underestimated their knowledge, while six reported over-estimation. Five studies reported a relationship in that higher confidence was associated with better knowledge. This finding suggests that in some areas, PSTs may not be aware of their lack of knowledge and that measures of perceived knowledge should be treated with caution. This is particularly relevant as in the search for this review, many more articles that reported on perceptions of knowledge were found than those that measured actual knowledge. Those researching PST knowledge should not rely on self-reports alone, but must include some measure of actual knowledge to increase the likelihood of accurate findings. It is clear that where PSTs report low levels of knowledge, or a need for further education, these reports should be taken seriously.

Twenty studies included some analysis of the effects of various factors. No consistent effects emerged apart from the unsurprising findings that students in later years of a course did better than those in the early years, and those entering with more prior experience in a content area did better than those with less prior experience.

Assessment of the knowledge of PSTs is a contested area (Allard, Mayer, & Moss, 2013) but this article is not the place to debate how it is best done. There may indeed be other ways of demonstrating the impact of teacher education programs or the knowledge of PSTs, but this article is limited to those studies that have made an attempt to directly measure knowledge or skills. A limited number of articles were located, and several of these came from citation and ancestral searches, so it may be that even with the range of search terms used some relevant studies have been overlooked. It is also important to acknowledge that teacher effects are only one class of effects that contribute to school student outcomes, and teacher attributes other than knowledge, such as attitudes, beliefs, and self-efficacy may also play a part (Hattie, 2009).

The results of this study do provide some support for the introduction of assessments (ACER, 2016) to ensure PSTs have some basic literacy and numeracy content knowledge. As Livy et al. (2012) pointed out in regard to maths content knowledge, universities cannot assume that PSTs have adequate knowledge of primary school mathematics, and the studies here on basic literacy also demonstrate serious deficiencies in many PSTs. The results also suggest that PST knowledge in other areas (such as global warming and sustainability) cannot be assumed, even though this content is part of school curricula.

Overall, it is clear that teacher education programs must address content knowledge along with the other forms of knowledge required by teachers, and that assessment, and where necessary, remediation of basic literacy and numeracy should be part of teacher education programs. There is also a clear need for more research that compares the outcomes of PSTs prepared in different ways, and less research that investigates the impact of a single unit. Universities must be open to more research that allows these comparisons to be made, as well as research that explores general levels of PST knowledge.

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Appendix

Article	Inadequate	Mixed	Adequate	Exam conditions
Literacy				
Bennet & Lancaster (2012)			✓	N
Bostock & Boon (2012)	✓			?
Dawkins et al. (2009)		✓		N
Fenwick, et al. (2014)		✓		N
Fenwick et al. (2013)		✓		N
Fielding-Barnsley (2010)	✓			Y
Fielding-Barnsley & Purdie (2005)	✓			Y
Geng (2013)	✓			Y
Geng & Disney (2014)	✓			Y
Harper & Rennie (2009)	✓			Y
Mahar & Richdale (2008)	✓			Y & N
Meehan & Hammond (2006)	✓			Y
Moon (2014)	✓			Y
Tetley & Jones (2014)	✓			N
Thwaite (2008)			✓	Y
Numeracy				
Beswick & Goos (2012) (for maths content)	✓			N
Beswick & Muir (2013)	✓			N
Goos (2013)	✓			N

Klinger (2011)			✓	Y
Livy & Herbert (2013)	✓			Y
Livy et al. (2012)	✓			Y
Livy & Vale (2011)	✓			Y
Norton (2010)	✓			Y
Norton (2012)		✓		Y
Prieto et al. (2015)		✓		N
Ryan & McCrae (2006)		✓		Y
White et al. (2006)	✓			N
Child protection				
Brown (2008)	✓			N
Clarke & Healey (2006)			✓	?
Goldman (2005)			✓	Y
Goldman & Bradley (2011)		✓		Y
Goldman & Grimbeek (2008)		✓		N
Sustainability				
Boon (2011)	✓			N
Effeney & Davis (2013)	✓			N
Odgers (2009)			✓	?
Stir (2006)	✓			N
Taylor (2006)	✓			Y
Global warming				
Boon (2010)	✓			?
Boon (2015)	✓			?
Science				
Lloyd & Mukherjee (2012)	✓			N
Mulholland & Ginns (2008)		✓		N
Students with special needs				
Anderson et al. (2012)	✓			N
Bain et al. (2009)			✓	Y
Bryer & Signorini (2011)		✓		N
Self injury				
Berger et al. (2015)		✓		N
Evidence-based practice				
Carter et al. (2015)	✓			N
Communication skills				
Cavanagh et al. (2014)	✓			N
Values education				
Christian (2014)	✓			N
Physical education				
Dudley & Baxter (2009)		✓		Y
Equity				
Fenwick & Cooper (2013)			✓	N
Behaviour management				
Yeigh (2013)			✓	N
ICT				
Fluck & Dowden (2011)			✓	N

Table 1: Adequacy of PST Knowledge and Conditions in which it was assessed.