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Abstract: The purpose of study was gain insight into pre-service teachers' experiences in using classroom data to make learning and teaching decisions. The qualitative study is based on the reflections and recommendations of three pre-service teachers' that participated in a data-driven decision-making intervention whilst on an immersive 10-week professional learning experience. This study is underpinned by an action research framework. There are many understandings of action research, here the approach is understood to be a systematic investigation into one's own practice with the aim of improving teaching and learning. From the thematic analysis of the reflections, several recommendations were put forward by the pre-service teachers. They advocated for dedicated time to develop data collection, analysis, and visualisation skills and that these skills should be embedded in their degrees. Their reflections articulate the need to have a strong set of data related skills and competencies in order to be able to engage with professional practice.

Introduction

This article presents the reflections and recommendations of three pre-service teachers and is based on their experiences of participating in a data driven decision making intervention whilst on an immersive professional learning experience. This research study is part of a larger research interest on data literacy in initial teacher education. The larger research study is aimed at finding pedagogical strategies to develop pre-service teachers' data literacy and data-driven decision-making processes. In other parts of the study, we have addressed the use of action research in pre-service teacher education to develop data literacy (Kennedy-Clark, Galstaun, Reimann, & Handal, 2020; Kennedy-Clark, Eddles-Hirsch, Francis, Cummins, Ferantino, Tichelaar, & Ruz, 2018), the role of data in pre-service teacher education (Kennedy-Clark, Galstaun, Reimann, & Handal, 2018); and we have put forward a theoretical framing for the development of data literacy (Kennedy-Clark & Reimann, submitted). In this paper, we focus on pre-service teachers' perspectives of collecting and using data. The pre-service teachers had to analyse how their own teaching practices, whilst on a 10-week professional learning experience, were impacted upon as a result of their action

research project.

From a research perspective, whilst the number of publications on data literacy has increased over the past decade, there is still much room for contribution to research in this area (i.e. there are currently around 28 publications directly relating to data literacy according to Henderson and Corry (2020)). The research has addressed diverse areas; for example, some studies have put forward definitions of data literacy (Mandinach & Gummer, 2015); some have covered investigations of student learning and school improvement decisions (Bocala & Parker Boudett, 2015; Coburn & Turner, 2012); others have outlined professional development initiatives (Marsh, Bertrand & Huguet, 2015); a few have discussed student-involved data use (Jimerson, Cho & Wayman, 2016); and other studies have addressed strategies for developing professional learning courses (Datnow & Hubbard, 2015; Jimerson & Wayman, 2015; Mandinach, Friedman, & Gummer, 2015) and some have covered pre-service teacher education (Reeves & Chiang, 2017). Most of the studies have focused on teachers and teacher professional development. What seems to be missing from these studies is a substantive focus on initial teacher education programs and the actual voices of the individuals that are involved in these interventions. That is, the research that is put forward is from the perspective of the researchers rather than the participants or pre-service teachers.

In this paper, space was given to pre-service teachers to share their reflections on a data driven action research project and to make their own recommendations on how best to embed data literacy into pre-service teacher education courses. The rationale underpinning this claim is that involving pre-service teachers in the data collection and analysis process may contribute to better ways of making classroom decisions and catalysing their own motivation to develop their data use skills (Marsh, Farrell, & Bertrand, 2016). This paper is, therefore, positioned from the argument that we need to know more about the conditions under which pre-service teacher data literacy may affect improved student outcomes. It is also posited here that we, as initial teacher educators, need to know about the practices that that give rise to pre-service teacher confidence and understanding of how to collect, analyse, and use data in the classroom. This paper presents the reflections and recommendations of three of the third-year education students that participated in the study. The study asks the research questions: a) what are pre-service teacher reflections on collecting and using data in the classroom; and b) what are pre-service teacher recommendations for improving pre-service teacher education on using data for learning and teaching purposes?

Background

Professional Learning for Professional Development

There have been calls in the research for university-based teacher preparation programs to develop a classroom-based focus by presenting preservice teachers with more opportunities to learn about real problems of practice (Diem & Carpenter, 2013). Professional learning placements (i.e. practicums) provide pre-service teachers with the opportunity to dovetail ideas and theories from theory-based courses with their own experience of observing and teaching in classrooms, particularly, in relation to their teaching areas. Another benefit of professional learning is that pre-service teachers can begin to develop a professional knowledge and understanding of teaching and to gather evidence to demonstrate graduate level Australian Professional Standards for Teachers as developed by the Australian Institute for Teaching and School Leadership (AITSL) (AITSL, 2011). Recently, AITSL (2017) introduced a mandatory Teacher Performance Assessment (TPA) in Australian initial teacher education courses that acts as a final capstone assessment in pre-service teachers' final internships. It is noted by Adie and Wyatt-Smith (2019) that the TPA will function as a

gatekeeper to ensure that all graduating pre-service teachers can demonstrate that they meet the Australian Professional Standards for Teachers. This will require that a pre-service teacher has mastery of their pedagogical and content knowledge, as well as a level of data literacy sufficient to understand and make use of data to inform classroom decisions and to be able to reflect upon and write about their data use and decision making.

Data Literacy in Pre-Service Teacher Education

From the research on data literacy, a comprehensive and seminal definition has been put forward by Gummer and Mandinach (2015):

> *Data literacy for teaching is the ability to transform information into actionable instructional knowledge and practices by collecting, analyzing, and interpreting all types of data (assessment, school climate, behavioral, snapshot, longitudinal, moment-to-moment, and so on) to help determine instructional steps. It combines an understanding of data with standards, disciplinary knowledge and practices, curricular knowledge, pedagogical content knowledge, and an understanding of how children learn. (p. 2)*

From the definition, it is evident that there are a number of elements that comprise the term data literacy, and these elements address teachers' beliefs about data literacy as well as their capacity and understanding of data literacy. Many of the studies investigate the role of the teacher in the uptake of school-based data literacy initiatives. For example, Brown, Lake and Matters (2011) argue that teacher "buy in" is central to the process of using data to inform their decision making. Other research strands, such as Datnow and Hubbard (2016) focus on capacity building in enabling teachers to collect or access the appropriate data, articulate meaningful questions, interpret the data and apply findings to their own teaching and classroom practice.

Data collection and teacher reflection on data use are also seen as critical in meeting the learning needs of a diverse student population, and a number of studies have shown that data-driven decision-making can lead to an increase in student achievement (Campbell & Levin, 2009; Lai, McNaughton, Timperley, & Hsiao, 2009; Mandinach & Gummer, 2013; Schildkamp & Poortman, 2015). However, being able to collect and use data meaningful requires a degree of self-regulation, and this also presents challenges both for pre-service teachers and pre-service teacher educators (Michalsky & Schechter, 2018). The study at hand focuses on pre-service teachers' reflections of how they translated data into information (e.g., interpret data, understand data representations) and how they transform the information that they have collected into a decision (e.g., lesson design and assessment).

Research Design

The need to undertake inquiry that positions the teacher as an action researcher so that they are able to reflect on practice and make independent curriculum data-driven decisions, has been outlined in the research as an important focus in a teacher's role (Cochran-Smith & Lytle, 2009; Fecho & Allen, 2003). Other studies, such as Bywater's (2014) study, have shown that getting college-level students to undertake professional-based action research had tangible benefits for the student researchers in developing their professional and social capabilities as well as context appropriate research skills. Action research provides an appropriate platform to support pre-service teachers in developing their research skills, data literacy, and data-driven decision making.

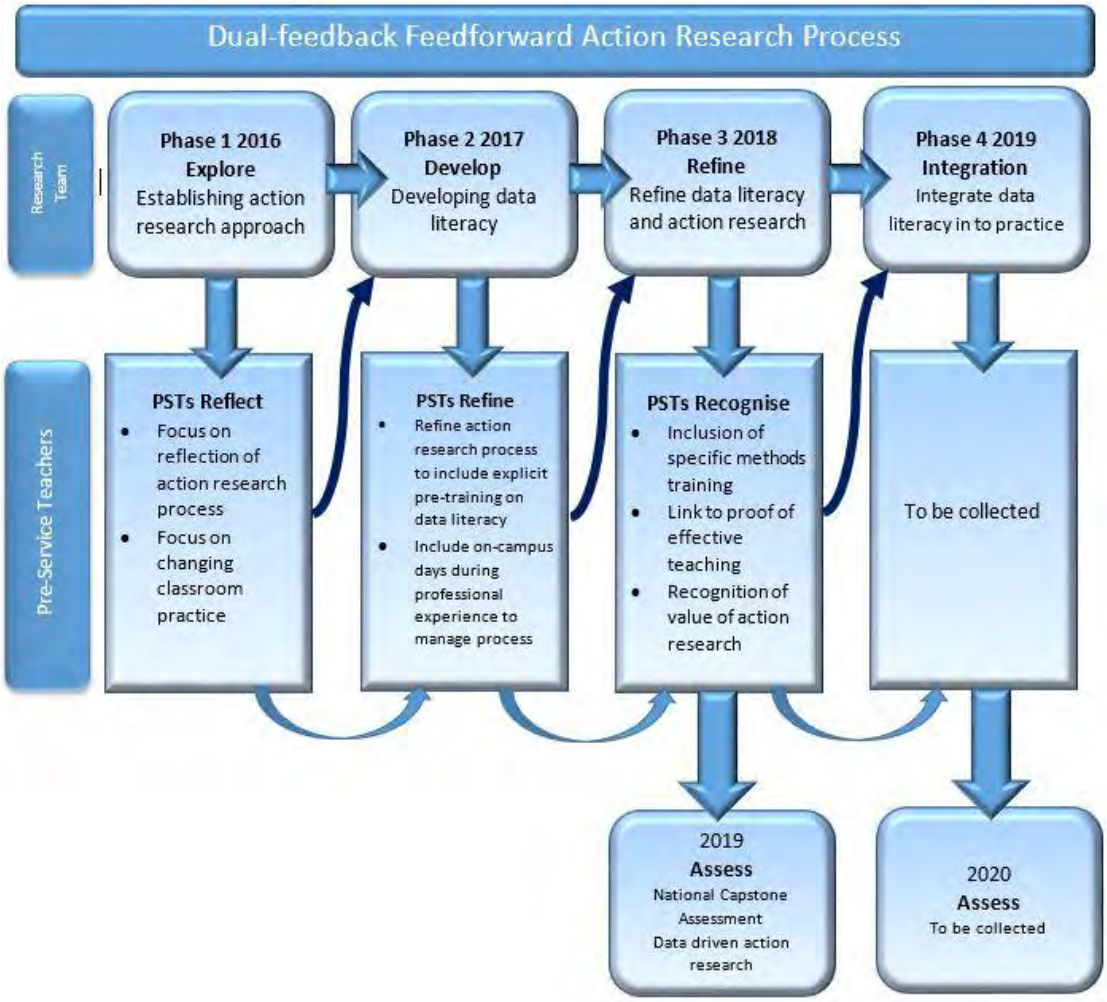

Figure 1. Dual-feedback feedforward action research model

This study is underpinned by an action research framework (Figure 1). This paper is based on data collected during Phase 3 of the study. In this model, feedback from the pre-service teachers is used to feedforward into our research design and into the pre-service teacher's own capstone action research project (i.e. the TPA) that must be completed in their final internship. While action research is known for its cyclical design, in this study, there are two channels of feedback that are used to inform subsequent iterations. There are many understandings of action research, here the approach is understood to be a systematic investigation into one's own practice with the aim of improving teaching and learning (Ulvik & Riese, 2016). Action research has been well-documented in pre-service teacher education (see, for example, Cochran-Smith and Lytle, 1999; 2009). Smith and Sela (2005) outline myriad benefits of using action research in pre-service teacher education including making the teacher an active agent of change; giving teachers a voice in the research on education; supporting teachers in developing skills to make pedagogical changes; and that change in education begins in the classroom. Here, we draw upon Winn's (1995) research that documented that by using a 'learning by doing' approach to teaching research methods in context that students' understandings of what is involved in the process of doing research whilst on professional placements improved as did their interest in research and data collection methods in general.

Participants

Purposeful sampling was used to select the participants. Purposeful sampling is frequently used in qualitative research for the identification and selection of information-rich cases that are related to the phenomenon of interest (Palinkas, Horwitz, Green, Wisdom, Duan, & Hoagwood, 2015). There were 27 pre-service teachers in the 2018 cohort, and all were invited to participate in the collaborative writing of this paper. Three pre-service teachers volunteered to participate in the study and contributed written reflections. Two of the participants were female and one was male. All three were aged between 20 to 25.

The pre-service teachers were asked to write their reflections after their grades had been confirmed for the course so that there were no perceived benefits or coercion from participating in the study. The pre-service teachers that contributed the written reflections were also advised of the publication process and that they had full control over how they were represented in the paper. It should also be acknowledged that the academics involved in the study are also participants in that we use the data to refine the research study and the course materials. HREC Ethics approval was obtained for this study approval number 017101S.

Data Collection and Analysis

The data comprised a written reflection from the three pre-service teachers. The pre-service teachers were asked to write a critical reflection on the development of their data literacy during the action research. There was a word limit guide of 500 to 1000 words. Guiding questions were given in order to help the pre-service teachers to articulate their reflections. These are the guiding questions: 1. Define data literacy in your own words? 2. Why are you being asked to develop your data literacy? 3. What were your experiences of doing an action research project whilst on professional experience? 4. What are the benefits of developing your data literacy? 5. What are the challenges? 6. Where and how should data literacy be embedded in pre-service teacher degrees? And 7. Concluding thoughts? The reflections were coded against themes that arose in Phase 1 and 2 of the research study. The first two questions were designed to elicit the pre-service teachers basic understanding of what data literacy means and why the pre-service teachers were expected to develop their own personal data literacy (rather than their students').

The process was steered by Braun and Clarke's (2006) procedure for conducting the thematic analysis. Braun and Clark (2006) argue that a rigorous and systematic thematic analysis can produce trustworthy and insightful findings. According to Nowell, Norris, White, and Moules, (2017) thematic analysis is a useful approach for summarising the key features of a large data set as it enables the researcher to adopt a structured approach to handling data. However, as Nowell et al. (2017) also note, there is no clear agreement about how researchers can, rigorously, apply the method. As such, we adopted a dual coding approach to build validity into our findings, and the first and second authors coded the reflections. The process adopted for this consisted of six steps. Initially, the entire data set, including reflections from Phase 1 and 2, was read three times and preliminary ideas for themes were established through negotiation. Secondly, all items were reviewed and manually coded for the emerging themes. The codes were matched with the critical reflections across the three phases. The themes were then reviewed and refined and agreed upon by the research team. Next, the themes were defined and named. Finally, four major themes were articulated and agreed upon by the research team. The first and second authors then revisited and reviewed the three reflections presented here against the themes. The

results provide a summary of the key findings and a more detailed analysis of the participants' and co-authors' reflections. We adopted Nowell et al's (2017) approach of presenting both shorter quotes within the narrative to demonstrate that the three participants were represented across the results. We have also presented themes and main findings in a table (Table 1), which aided us in presenting the results. The paper was submitted to the participants prior to submission for their feedback as a process of member checking (Côté & Turgeon, 2005).

Results

The three pre-service teacher reflections were coded against the four main themes. These themes are: *Pre-service teacher reflection on action; Pre-service teacher data literacy conceptualisations; Pre-service teacher research process management;* and *Pre-service teachers' perspectives on professional practice*. The results draw upon relevant literature as Braun and Clarke (2006) recommended that in a thematic analysis that the researchers aim to articulate what each theme means, outline the assumptions that underpin it, and clarify the implications of each theme. Braun and Clarke (2006) maintain that the final analysis should be presented as a narrative about what the different themes reveal about the topic. As such, there is an element of discussion in the results as the first two authors drew upon relevant literature to understand the findings. The main findings are presented in Table 1. The themes are then elaborated using pre-service teachers' own reflections.

Theme	Main Findings
Theme 1. Pre-service teacher reflection on action	• Action research is challenging • Action research develops confidence in effective teaching • Action research builds validity into teaching • Action research provides space for critical reflection whilst on professional learning
Theme 2. Pre-service teacher data literacy and data skills conceptualisations	• Data literacy involves systematically utilising and analysing data in order to make decisions in the classroom • Data literacy and data skills development should be embedded throughout all stages of an education degree • Data literacy and data skills are best developed during authentic professional learning • Appropriate data can be used to inform and transform teaching • Mentoring and one-to-one support are beneficial in adjusting research aims and data analysis
Theme 3. Pre-service teacher research process	• Time management and time constraints are enduring factors in the undertaking of professional learning action research projects • Integrating data collection with an existing teaching strategy maintains workload • Time is needed during (on-campus days) and after (course work) to provide space for critical reflection
Theme 4. Pre-service teachers' perspectives on professional practice	• Data literacy is a necessary skill for a pre-service teacher • Data literacy should be mandatory in all education degree programs • Data literacy is a fundamental component of assessment and achieving the Australian Professional Standards for Teachers • The effective use of data can provide measurable proof of ongoing learning • The effective use of data enables teacher and school accountability

Table 1. Pre-Service Teacher Data Literacy and Data Skills Themes

The pre-service teacher reflections provides a rich source of information regarding their lived experiences. Here, the themes are unpacked using the reflections.

Theme 1. Pre-Service Teacher Reflection on Action

In this theme, the central idea of the value of reflection on action is outlined. Looking to Dewey's (1910) seminal text, finds the roots of reflection where reflective action stems from the need to solve a problem. As pre-service teacher 1 states:

> *The completion of the action research project, not only allowed me to develop confidence in using both qualitative and quantitative methods of data, but also provided a clear conclusion about what was working and what wasn't in terms of teaching and learning strategies. It provided an opportunity for reflection, and initiated changes within my own teaching style and outlook. [Pre-service teacher 1]*

Dewey's (1910) work is of significance to this theme in relation to his belief that education must engage with and enlarge experience. In this sense, from reflection, pre-service teachers can see ways to improve the action research experience, if not for them then for the next cohort of pre-service teachers. With this, pre-service teacher 1 adds:

> *Overall, the experience of formulating my own action research project in a secondary school was great and has now made me feel a lot more confident in collecting and using data when I graduate university at the end of this year. [Pre-service teacher 1]*

Sch n (1987) recognised that professional knowledge lies in the doing of the job, where many teachers cannot articulate what they know, they just do it. Through critical reflection on practice we are able to examine the technical aspects of our teaching, as well as looking practically and critically at issues within the school and outside that might impact on the quality of teaching and learning in the classroom. Pre-service teacher 2 reflects upon the change in their own views as a result of undertaking the project:

> *Although this experience was both challenging and rewarding, I ultimately believe it enabled me to understand the importance of data within the classroom, which I had previously dismissed. [Pre-service teacher 2]*

An important feature of the reflective practice is the relationship with professional knowledge and practice. The value of reflection to feedforward into improving teaching is neatly summed up by Brookfield (1987) who declared that through reflection we look at all the things we do, the things we never stop to think about or ask questions about, and that as reflective teachers that we should try and unpack the assumptions about what we do in the classroom in order to be better teachers tomorrow. This is demonstrated through the reflections of pre-service teacher 2:

> *Before this project I had little experience with interpreting data, and no experience with collecting or displaying data, thus my inexperience affected my confidence and self-efficacy. However, this was a challenge I was able to overcome, learning through workshops how to effectively collect and display data, whilst also being provided with a scaffold of how to format an action research project. [Pre-service teacher 2]*

Reflectivity in pre-service teacher education enables novice teachers to develop an orientation towards inquiry and the ability and need to think about their professional and theoretical experiences. Pre-service teacher 3 reflects upon the links between professional learning and the rigours of academia, illustrating the connection between theory and practice:

> *The academic rigour of a full action research assignment forced careful reflection on content and methods in the research, and generated an in-depth article that is useful for reference. [Pre-service teacher 3]*

Pre-service teacher 3 also raised the transition between professional learning university-based course work:

> *There were clearly significant benefits to undertaking action research whilst on professional experience. The process forced the teacher to continually reflect on teaching practice against the data collected, and kept me engaged with rigorous academic practices that assisted in the transition back to regular university classes. [Pre-service teacher 3]*

Through reflectivity based on action, pre-service teachers have space to examine their own beliefs and practices about teaching and to reach context-specific decisions. All of these factors are considered to be the main characteristics of effective teachers in the classroom.

Theme 2. Pre-Service Teacher Data Literacy Conceptualisations

This theme addresses how pre-service teachers collect data and how they use the data. In this sense, it is what the pre-service teacher does. It also addresses their views on data literacy. This is reflected in pre-service teacher 1's response:

> *It bridged the gap between content taught at university and real life application within a classroom. From my understanding, data literacy involves systematically utilising and analysing data in order to make decisions in the classroom. The results from the data, after analysis, will translate into actions, so as to continually improve teaching and learning. [Pre-service teacher 1]*

The pre-service teacher also links theory to practice with:

> *I believe, it is the most effective way to embed the skill of being data literate in pre-service teachers… the best way to develop teacher data literacy skills, involves being taught how to collect and analyse data, and for this new knowledge to be applied and tested in a practicum that follows learning this knowledge. [Pre-service teacher 1]*

Data literacy, therefore, draws upon an understanding of aligning data with standards, disciplinary knowledge and practices, pedagogical content knowledge and how children learn in order to make effective and appropriate learning decisions (Gummer & Mandinach, 2015). Pre-service teacher 2 reflects upon the research of Gummer and Mandinach in her response:

> *Data literacy, within teaching, is a teacher's ability to transform evidence, such as test scores, observations and school climate into data. It is from this data that conclusions can be drawn and alterations to teaching practice can be made. The common belief within the discourse surrounding data use in teaching, is that teachers skilled in data literacy will lead more successful and effective classrooms, ultimately improving student performance (Mandinach & Gummer, 2016; Konstantepoulus, Miller & van der Ploeg, 2013; Carlson, Borman & Robinson, 2011). [Pre-service teacher 2]*

A primary goal of professional development is to support educators to establish effective data practices that are both consistent with current research findings and resilient in that the adoption of the process is ongoing (Adams Frey, 2009). Pre-service teacher 2 explains that through engaging with this project, she was able to deepen both her data and research skills set; however, she also developed an understanding of the value of evidence-based practice.

> *This project allowed me to develop my data literacy through practical application, this encompassed multiple benefits. However, this task ensured I collected and arranged my own data, finally beginning to understand the importance of evidence-based research to inform teaching practice. [Pre-service teacher 2]*

The research on professional development in data literacy raises several consistent characteristics for good practice: a collaborative approach; authentic examples from classrooms and schools; context specific; consistent with prior learning; and intellectually engaging (Jimerson & Wayman, 2015).

> *Through completing this project, I gained the insight that it is important that pre-service teachers have the confidence to use data as evidence to inform classroom practice. [Pre-service teacher 2]*

Pre-service teacher 3 acknowledged that he has a highly developed understanding of statistical analysis and that he understood exactly what types of knowledge were needed to engage with the process:

> *The project relied heavily on extensive and detailed data, which required high-level data literacy skills. [Pre-service teacher 3]*

These findings are consistent with the findings of Carey et al (2018) who found that by embedding data literacy learning within professional experience coursework enabled their students to gain authentic contact with the classroom application of data. They further argued that a link was established between having an assessment task on data literacy and professional experience. Kosnik and Beck (2000) provide a more metered response in that they found it difficult to assess the impact of doing action research in pre-service teacher education separately from the effects from other aspects of the professional placement, such as the experience gained simply from being in the classroom. However, they confirm that action research is valuable as pre-service teachers have ownership of the task. From these reflections, we can see that the pre-service teachers see the value of developing a set of data-based skills and competencies.

Theme 3. Pre-Service Teacher Research Process Management

This theme addresses pre-service teachers' management of the action research process. There is consistency in the literature on action research in pre-service teacher education that is challenging for the pre-service teachers and that time constraints seem to be the most common cause of consternation, see, for example, Dobber, Akkerman, Verloop, and Vermun (2012) and Ulvik and Riese (2016). It is contended that pre-service teachers need guidance in the action research process and that the process needs to be embedded within a larger theoretical framework. In this respect, the pre-service teachers need to know about *the how*, *the what* and *the why* (Cochran-Smith et al. 2009; Kosnik & Beck, 2000). Pre-service teacher 1 explains some of the knowledge required to manage the process:

> *The large amount of time that was provided after placement for reflection and refining our data however, was extremely beneficial. Challenges in relation to variables that were uncontrollable, such as student absences, school assemblies etc. often made collecting reliable and valid data difficult, especially when time constraints were present. [Pre-service teacher 1]*

In regards to the pragmatics of undertaking an action research project whilst on professional experience, time management has been an enduring issue both in our project and in the literature on students undertaking research projects as part of their coursework. Cutler (1987) documented over thirty years ago that there is a need to ensure that students have

realistic expectations at the outset of the project. Pre-service teacher 2 discussed the challenges that arose:

> *It was a challenge to tackle the workload of both simultaneously. It was a challenge to orientate myself in the project. It was a challenge to focus on teaching whilst also aiming to collect observational data. It was a challenge to interpret the data. It was also a challenge to display the data. [Pre-service teacher 2]*

Educators need to ensure that there is a feasible workload for both pre-service teachers and educators. In this phase of the research, the inclusion of on campus days meant that pre-service teachers had "time-out" from their professional experience to discuss their projects, which meant that time management issues could be addressed. As demands on pre-service teachers' time may have been greater at some points in the school term than at others, having two on campus days provided space to reflect upon the action research projects without the competing pressures of teaching and preparation. However, it is also noted that the logistics of undertaking a research project in the available time does present problems, and it has been noted that one semester is not a lot of time to actually complete a research project from beginning to end (Nyden, 1991). Managing the workload is reduced by integrating the data collection with existing teaching strategies, as pre-service teacher 3 explains:

> *Using formative and summative assessment, I collected data on academic performance and self-efficacy. The project itself was not overly demanding during the teaching period of the professional experience. The formative assessment data was easily integrated into existing teaching practices. My classes engaged in active reflection at the conclusion of each lesson, by completing an Exit Ticket. Using an existing teaching strategy for my action research project maintained my workload rather than increasing it, and created an opportunity for me to critically evaluate part of my teaching practice. [Pre-service teacher 3]*

According to Dobber et al. (2012), in order for an action research project to be successful, it must be grounded in the pre-service teacher's own work and questions. In this sense, pre-service teachers need also to have some form of contribution to how the assessment, for it is an assessment, is managed by the pre-service teachers and the educators. Pre-service teacher 3 provides insights into how the workload, and the assessment, can be managed over the course of a degree:

> *A mandated action research project is beneficial, but students should also be encouraged to engage in more informal methods of action research by integrating these practices into their teaching… A simple solution would be to provide pre-service teachers with a highly scaffolded and less academic version of an action research project during their first professional experience. This reduced action research project would serve as a preparation for a full action research project in a future professional experience, which would be of a higher quality due to the experience gained. [Pre-service teacher 3]*

What comes from these insights is that if the pre-service teachers had been introduced to research and data collection methods earlier in their degree program, much of the associated anxiety could have been mitigated. In this sense, had we, the teaching team, given more time to teach the pre-service teachers about collecting, analysing and visualising types of data from first year then they could have been better prepared to manage the process. It should be noted here that on the basis of findings from 2017 that the pre-service teachers here did have explicit training in an intensive week before their placements and the 2019 cohort

(Phase 4) will have undertaken data literacy courses in their second and third years in preparation for project. Hence, we too, as part of the feedforward process, learn from the action research experiences of our pre-service teachers.

Theme 4. Pre-Service Teachers' Perspectives on Professional Practice

This study moves data literacy from the university classroom into professional learning via an action research project. This process of embedding data literacy into professional experience has been called for in the research, see, for example, Carey et al. (2018). All of the pre-service teachers confirm this argument in their reflections:

> *The importance of data literacy in schools has become increasingly apparent. This is evident from the development of data literacy skills being a focal point for pre-service secondary education students. As much as this collection of data assists teachers to keep on top of student progress, this collection of data is also used to hold teachers accountable. [Pre-service teacher 1]*
>
> and
>
> *Thus, as the professionalism of teaching grows it is vital that pre-service teachers learn how to effectively use data, ensuring their classroom practices are evidence based, hopefully leading to more successful classrooms and enriched pedagogy. [Pre-service teacher 2]*
>
> and
>
> *Despite the increasing requirements being placed on pre-service teachers, some form of embedded action research is critical for developing data literacy, as the potential skills gained will allow teachers to unlock powerful observations and conclusions that can make meaningful changes in their classrooms, and the learning experiences of their students. [Pre-service teacher 3]*

Carey et al. (2018) further add that embedding data literacy into a supervised professional experience with time for reflection and discussion after the professional experience can address the disconnect between university and professional experience. What was noted by the pre-service teachers was that the process enabled them to connect with the Australian Professional Standards for Teachers, as pre-service teacher 1 reflected:

> *The Australian Professional Standards for Teachers, which all pre-service students at my university were made aware of before entering our first practical placement, includes standards such as using data to evaluate current teaching and learning methods, and using this data to inform future planning. This, therefore, makes it essential for pre-service teachers to be taught the skills involved with effective data literacy. Without being taught these skills, pre-service teachers are left with a naïve understanding about data, and feel lost and uncomfortable when faced with these requirements during placement or when entering their first teaching job. [Pre-service teacher 1]*

Cochran-Smith and Lytle (1999) recognise that there has been a renewed interest in action research and teacher as researcher since the 1980s as their unique knowledge regarding their own classrooms means that they can have a positive impact upon learning decisions. Action research has also been shown to prepare pre-service teachers for the workplace (Carey et al. 2018; Cochran-Smith & Lytle, 1999; Kosnic & Beck, 2005). This workplace readiness and concept of preparedness is reflected in the comments by pre-service teacher 2:

> *I was able to reflect, think, decide and integrate through the completing of an action research project, whilst on professional experience. Thereby through developing my data literacy I have become more equipped for the "real world"*

> *of teaching, I will now be able to integrate evidence-based research into my classroom, hopefully leading to a more effective learning environment. [Pre-service teacher 2]*

In regards to pre-service teachers as researchers, Hammerness et al. (2005) in their research on preparing pre-service teachers for the classroom put forward the claim that graduate teachers from teacher education programs that made extensive use of teacher as researcher approaches had significantly higher feelings of preparedness for the workplace and were rated more highly by employers than those that did not. Hence, the action research process not only provides space to develop requisite teaching and learning skills but can also be seen as a means of professional capacity building.

Discussion

The findings of this phase of the research, from the perspectives of the educators, support the literature that argues that hands-on activities, even at a university level, enhance students' learning and deepens their understanding of the course content and enables skills development (e.g. Brown et al, 2011; Bywater, 2014; Dunlap & Prio, 2016, Winn, 1995). As with all skills, practice is needed not only to develop mastery of skills, but also to identify gaps in knowledge and competencies. Research on skills and competence development shows that this takes time see, for example, Ericsson, Charness, Feltovich, and Hoffman (2006). Ericsson et al. (2006) articulate that time needs to be devoted to explicit instruction and deliberate practice, with the unambiguous goal of skill improvement. This goal setting and instruction should be coupled with just in time feedback. Feedback contingent on individual practice is necessary for skill development, as with many other forms of learning (Hattie & Timperley, 2007). What we argue here is that we need to backfill our degree programs in order to build in mastery experiences in a similar way in which we develop data literacy across several years. However, these are our views, through giving space to hear the voices of the pre-service teachers, we can gain a better understanding of what they believe they need to develop the requisite skills and competencies in their degree programs.

From the analysis of the reflections, several recommendations were put forward by the pre-service teachers. They advocated for dedicated time to develop data collection, analysis, and visualisation skills and that these skills should be embedded in their degrees from the first year of their degree. They argued that this will enable them to gain mastery of the data collection before they are immersed in their professional experience. In this sense, they will develop the capacity to self-regulate their own professional learning. It was also stated that by gaining mastery over the data collection side of the action research that they could couple data collection with their existing teaching strategies (e.g. exit cards, pre-mid-post-tests, and classroom observations). The pre-service teachers also advocated for mentor style relationships with supervising teachers during their placements, so that they had access to an expert to share their ideas with and to refine their approaches. They confirm that action research, whilst time-consuming, gave them space to reflect upon their own professional learning and the learning of their students. They confirmed that they were able to use evidence from their teaching to prove that their students were learning. This in turn built confidence in their effectiveness as teachers. One stream of thought arising from the reflections was in relation to professional preparedness in that through undertaking the project, they felt better prepared for the workplace and more confident in their abilities as classroom teachers.

What stands out from the reflections is the conceptualisation of self-assessment, taking risks, and professional learning. The pre-service teachers, as part of the process, needed to take learning and teaching "risks" in that they needed to implement strategies and then measure and reflect upon the impact of their choices. Opportunities to take such risks in the classroom and to then learn from these critical events is seen to be an essential experience in learning about teaching (Nilsson, 2009; Smith & Sela, 2005; Ulvik & Riese, 2016). In this study, the pre-service teachers had to try out something that they had not done before and then to reflect on the effectiveness of their intervention. This meant moving them beyond what they may have felt comfortable with in order to develop a new set of skills and perspectives to cope with the complexities and multifaceted challenges of teaching. The three pre-service teachers experienced positive outcomes from their action research, and their reflections indicate that they have developed a deeper understanding of the practice of teaching and the value of data to inform classroom decisions.

There are, of course, myriad limitations in this study. Firstly, this study is part of a larger research interest, and we are aware that we are not coming to the data with fresh eyes. In order to mitigate any potential biases, the study was presented to two peers for review in order to ensure that our findings were justifiable from the data collected. Secondly, we acknowledge that this was a small-scale study with three participants. However, given the consistency in the findings across the past three years, we are fairly comfortable in putting forward the results. Our future research interests lie in understanding the perceived impact of the pre-service teachers in the classroom. We would like to know what impact means to pre-service teachers and classroom teachers and how it can be measured.

Conclusions

When education preparation providers and pre-service teachers have access to the information they need in order to use data appropriately and accurately, they are better able to make informed decisions that lead to them being effective classroom teachers who are ultimately able to contribute to student success. What is of note is that in the current education climate of needing to have measurable outcomes, pre-service teachers need to be data literate. Their reflections clearly articulate that they need to have a strong set of data related skills and competencies in order to be able to engage with professional practice. A claim being put forward by the authors is that teacher education providers need to provide both the time and the resources necessary for skills development in data literacy that is beyond a basic level. The need, eventually, to develop data fluency. This is based on the claim pre-service teachers need actual time and exposure to authentic interactions with data literacy. Given that any course in pre-service teacher education will address a whole range of skills, the integrative process of action research enables pre-service teachers to link theory with practice and professional learning competencies.

Through enabling the pre-service teachers to undertake their own action research projects over the duration of an extended immersive period, the pre-service teachers feel better equipped and more confident in their skills. We also advocate that this is the best means to prepare them for the classroom and their professional careers. Perhaps the greatest potential gains from this type of action research project derive from the way in which it allows pre-service teachers to develop an understanding of the process of doing research by following a research project from its early stages to its conclusion. From this process, pre-service teachers develop data literacy, confidence in their ability to ask effective learning and teaching questions, and positive reinforcement from seeing the results of their teaching

improve student learning. Having these skills enhances the understanding of pre-service teachers on how evidence-based practice through using data can transform their understanding of teaching and learning.

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