DEVELOPING AUTHENTIC DATA LITERACY IN PRE-SERVICE TEACHER EDUCATION PROGRAMS THROUGH ACTION RESEARCH

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Abstract

In this paper, we discuss the results of a study that investigated how best to prepare Pre-Service Teachers (PST) for professional experience in an Australian university. Recently, there has been a gathering interest in data literacy in the higher education system. In order to develop the PST's data literacy, we developed an online module of work whereby PST worked together to produce a range of data driven visualisations. Forty-four PST participated in the study. Data sources discussed include PST post-intervention surveys and deliverable action research projects. The preliminary results of the study indicated that the perceived benefits of the data literacy initiative for PST was that it improved their teaching and understanding of what works in a classroom.

Introduction

Data literacy, as a graduate Pre-Service Teacher (PST) skill, is garnering increasing attention both in academic and government spheres due to the potential benefits for its application to learning and teaching strategies and the development of education policies. Competency in data literacy is seen to be beneficial in that it can inform decision making in regards to school and system improvement and in the determination of educational approaches on the basis of learning and teaching events, such as national benchmarking examinations (Datnow & Hubbard, 2015). It has been argued that educators need to be taught how to use data to: identify sub groups; challenge views on students and student progress; understand student thinking; and to confirm what they know about students (Quint, Sepanik, & Smith, 2008). It is clarified in the research that educators are increasingly responsible for using multiple sources of data about student learning and school improvement decisions (Bocala & Parker Boudett, 2015; Coburn & Turner, 2012). Educators and those training to be educators (i.e., PST) need mastery of more than content knowledge and pedagogical knowledge. They also need to be able to work individually and as part of collaborative conversations on using evidence to make instructional decisions (Bocala & Parker Boudett, 2015). The point being made in the literature is that educators need to be able to collect appropriate data to inform learning and teaching decisions and to be able to present these decisions and their effects to key stakeholder groups. They also need access to authentic classroom experiences, which can be problematic for PST as much of their experience is theoretical and placed outside of the classroom. This may result in a disconnect between developing data literacy skills and applying these skills to a classroom setting when they enter the workplace. This study was aimed at contributing to the development of PST's

digital and data literacy so that they could make informed educational decisions whilst on professional experience in a high school classroom. While students may seem to be more technologically connected in that they have access to a range of devices and have grown-up in technology rich environments, research has shown that this does not necessarily translate to confidence in using technology in the classroom or an understanding of how technology can be used to support learning and teaching decisions making (Martin & Ndoye, 2016; U.S. Dept. of Education, 2012). From being able to visualise data in meaningful ways, teachers can then make informed decisions about how to recalibrate and refine their own practice to better support their students.

The study reported on this this paper was undertaken as part of a research project between two Australian universities. The study centres on developing an understanding of how PST develop data literacy and how PST use both the language and skills to (a) describe results, (b) diagnose learning and teaching issues, (c) predict what will be happening in the future, and (d) design and develop appropriate visualisations of the data to communicate with key stakeholders. The research questions addressed in this paper are: What factors influence PST's design choices when selecting methods of data analysis? How do design choices impact upon understandings of learning and teaching data?

Background

Data literacy in the classroom is garnering increasing attention both in academic and government spheres due to the potential benefits for learning and teaching strategies and policies. The theoretical lens that underpins this research study is *multiliteracies*. It is put forward here that multiliteracies provides a valid framework for which data literacy can be unpacked and understood in pre-service teacher education. This section of the paper provides an overview of pertinent literature that has influenced the conceptualisation of the research study.

Data Literacy

There is a focused body of literature on the importance of teachers using data. This seems to stem from international calls to increase the visibility of evidence-driven practices in education. Mandinach, Friedman and Gummer (2015) draw attention to the increased focus on data literacy in their research by clarifying that governing bodies in the United States, such as the Council for Accreditation of Education Preparation, have recommended that data literacy is included in their national standards. They stress that teacher preparation programs need to include data driven processes in their programs. In their study into the prevalence of data literacy units in preparation programs, they found that 92 per cent of the institutions participating in the study had components of data use for education decisions integrated into at least one course. Although they do clarify that the actual extent of the training is often not clear (Mandinach, et al., 2015). What this does demonstrate is that at an international level, there is an increased focus on ensuring transparency in educational decisions on the basis of educational data.

The gathering interest in data literacy in the education system in Australia, where the study was set, has been linked to these international educational and economic trends. Researchers in Australia have indicated that there is a growing vertical accountability linked to the competitive economy and high standard of living. Bennett (2006) stipulated that it is the global economy that is driving this shift towards data and accountability as a highly trained and skilled workforce is good for investment and also for a high standard of living. A highly trained and skilled workforce is seen to be an economic asset. This in turn has pushed back on the schools to ensure that there is better transparency in reporting processes and increased accountability across the education sector from the schools through to the tertiary providers. Moreover, good data promotes transparency and accountability within the system; it provides stakeholders with the information that they need to make valid and informed decisions (Marsh, Bertrand, & Huguet, 2015). It can be argued then that the increased focus on data use may be underpinned by economic factors.

In the higher education sector, this drive is translated as a need to support PST to be able to make data-driven decisions to support learning and teaching in the classroom. Therefore, data literacy can be viewed as a favourable graduate capacity. *Data-driven decision-making,* or *data use*, refers to the process of making educational decisions on the basis of data (Lai & Schildkamp, 2013). We draw upon Lai and Schildkamp's definition of data here in the context of schools and education systems as information that is systematically collected, analysed and organised to represent some aspect of school. That data may be derived from qualitative and quantitative methods of analysis. Data literacy, in essence, refers to the capacity to manage, understand, evaluate, critique and present data in a meaningful way (Athanases, Bennett, & Michelsen Wahleithner, 2013). Data literacy for teachers includes three skill sets, with these being: (a) *problem-focused skills*, such as knowing how to frame questions, identify problems and to make informed decisions; (b) *data-focused skills*, which include knowing how to access, generate and interpret data; and (c) *process-focused skills*, which include knowing how to engage in collaborative inquiry and to evaluate cause and effect (Mandinach & Gummer, 2013). Hence, to be considered to be data literate, those training to or already working in schools should be able to understand, analyse, and to act upon multiple forms of data about student learning (Coburn & Turner, 2012). Data literacy, therefore, draws upon an understanding of aligning data with standards, disciplinary knowledge and practices, pedagogical content knowledge and knowledge on how children learn in order to make effective and appropriate learning decisions (Gummer & Mandinach, 2015). Data literacy for teachers is not simply being able to collect, analyse and present data, it is being able to understand multimodal forms of data to improve learning and teaching decisions, and, in this sense, it is linked to multiliteracies.

Multiliteracies

The theoretical lens that underpins this research study is multiliteracies. While multiliteracies is generally associated with school contexts, it is argued here that multiliteracies provides a valid framework for which data literacy can be unpacked and understood in PST education. The New London Group put

forward the term *multiliteracies* to explain the wide variety of multiplicities now understood as valid texts, literacy practices, and semiotic relationships. The New London Group (1996) were aiming to "broaden the understanding of literacy and literacy teaching and learning" (p. 61) by accounting for multiplicity in languages and textual forms. Cope and Kalantzis (2009) later reflected on why literacy is of value, and they posited, "Education provides access to material resources in the form of better paid employment; that it affords an enhanced capacity to participate in civic life; that it promises personal growth" (p.4). According to Smith (2017), a multiliteracies lens can enable a learner to see the ways in which people make meaning with multimodal texts by using a variety of both culturally and historically contextualised designs. Individuals may filter and layer these texts in a designing process and finally produce a redesigned product to suit their specific context. Additional knowledge processes advocated in multiliteracies pedagogy includes: theorising, functional and critical analysis of texts; appropriate and/or transformed application of new knowledge; and student agency where learners take risks, collaborate, solve problems, advise, and mentor one another in partnerships (Healy, 2008; Kalantzis & Cope, 2012). There is, therefore, a focus on using an overarching metalanguage to articulate a design process that can facilitate the refinement and redesign of an artefact or pedagogical approach. This is relevant to how PST can filter and refine the learning data that they encounter to make specific classroom decisions.

Table 1.

Theoretical Framework

Multiliteracies Characteristic	Data Literacy Skill	Event Description
Situated Practice	Problem focused skills Process focused skills	PST undertake an action research project (ARP) while on professional experience. The ARP is generated by the PST for their subject area and year group. This is an authentic classroom experience.
Critical Framing	Problem focused skills	PST must develop a research question to frame their ARP and must apply a design process.
Overt Instruction	Data focused skills	PST undertake a week-long intensive in teaching methods, collecting and using learning data and undertaking research in the classroom.
Transformed Practice	Process focused skills	PST apply their data collection and analysis to address their research question. PST develop a "journal article" to present their findings.

There are four key characteristics of the multiliteracies pedagogical approach that resonate with the development of a PST's data literacy. These being (a) *situated practice*, (b) *critical framing*, (c) *overt instruction*, and (d)

transformed practice. According to the New London Group (1996), *situated practice* is learning grounded in students' own life experiences drawing upon a constructivist understanding of how people learn. *Critical framing* provides a framework for developing critical questioning strategies within discourses. *Overt instruction* is the use of direct instruction to teach the required "metalanguages" to provide a linguistic understanding of the components of the texts and grammars. *Transformed practice* is where learners apply their new understandings to develop a range of revised artefacts. Table 1 articulates how the three skills sets for data literacy are underpinned by a multiliteracies theoretical framework. In summary, the theoretical framework generated for this study draws upon multiliteracies and requisite data literacies skills. It is envisaged that the theoretical framework will be added to and unpacked over the duration of the study.

Research Design

This study used a mixed-method approach to the data collection. Two sources of data are reported upon here. These being a post-intervention survey and document analysis (student journal articles). The study was conducted from July to November, 2017. Table 2 outlines the data collection schedule.

Table 2.

Data Collection Schedule

Month	Event
July	Intensive workshops on teaching methods, data collection and analysis, and action research. (Collection of workbooks and screen capture data - not reported on here) (1 week)
July - September	School placement where action research study was implemented. This included the collection of their data for their action research. Collection of research questions (not reported on here) (10 weeks)
September	De-briefing session (administration of post-intervention survey) (4 hours)
November	Submission of final assessment (collection of journal article). Additional de-briefing (20 minute individual consultation)

The study comprised a one-week intensive of 20 hours of face-to-face workshops in July; a ten-week professional experience block (school placement) in a local high school from July to September; and a follow-up de-briefing session in September where the post-intervention survey was administered. The submission of the final assessment (journal article) was in November. The PST were introduced to the metalanguage of basic statistics, such as *visualisation, data sets, mean, range*, and *outliers*. They were also given training in a range of applications that could generate box and whisker diagrams, scatter plots, and frequency tables. While it is not reported on in this paper, the research team were also investigating a range of learning conditions, such as the PST working in pairs either side by side (condition A) or via head set (condition B) to solve several problems using R. R is an online visualisation software.

After the intensive week, the PST had to undertake a 10-week school placement. Whilst on placement, the PST had to undertake an action research project on an aspect of their teaching that they identified as needing further consideration (i.e., an educational problem). The PST had to design an action research project that could demonstrate that their learning and teaching strategies had a positive impact upon their students learning and could demonstrate Proof of Ongoing Learning (POOL). The approach taken here was that action research is a systematic investigation into one's own practice with the aim of improving teaching and learning through professional development (Ulvik & Reise, 2015). It is argued that in order for action research to be successful in PST education, the project must be grounded in the student-teachers' own work and own questions (Ulvik & Riese, 2015). The PST had to collect learning and teaching data as evidence of the effectiveness (or not) of their strategy. They were required to collect a minimum of two sources of data, where one source of data had to produce empirical results that could be presented through a visualisation (box and whisker diagram, dot plot, etc.). In short, the PST in the first two weeks of their professional experience had to design a learning and teaching strategy to implement in one or more of their classes. For the following eight weeks of professional experience they were required to collect data to show that their intervention or strategy resulted in learning gains for their target population/s.

Participants

The study involved a cohort of 44 third year pre-service teachers at a metropolitan university in Sydney. Teacher education is a four-year degree. The pre-service teachers were studying two teaching areas, for example, maths and English. Thirty students completed the survey. This is a 68.2 per cent response rate and is viewed as an acceptable response rate in social sciences research (Nulty, 2015). All students completed the journal article. No persuasive measures or incentives were offered to participants.

Data Collection and Analysis

Pertinent survey results and preliminary analysis of the documents (journal article) are presented in this paper. The survey was a 15-item instrument that used both multiple choice and open-ended questions. The survey has been developed from a reflective survey used by Quinn and Kennedy-Clark (2015) on PST's perspectives of online learning. The documents that were collected were the PST's final assessment, which was a journal article. The PST were provided with a journal article scaffold and were required to write an introduction, background (literature review), methods, results, discussion, and conclusion. A simple descriptive analysis of the survey was undertaken. The results of several questions are presented here. A thematic analysis of the journal articles was undertaken. Preliminary results of the thematic analysis are presented here.

Results

Prior to analysing the PST's journal articles, which presented the findings of their action research study, the survey results were analysed. Only relevant survey results are presented here to address the research questions put forward in this paper.

The first research question asked: What factors influence PST's design choices when selecting methods of data analysis? Item two of the survey asked: Describe your action research project and why you selected this area for investigation (i.e., what did you do, how did you plan it, and why did you investigate this area). Given that this item was asking PST to describe their own studies that they undertook in their classrooms, there was a diverse range of answers. The research topics covered differentiation, gifted education, assessments, and communication. Also, given that the action research topics centred on investigating a problem within their classrooms, these topics all fall within the scope of what teachers would normally encounter in their classrooms. In survey item six, the participants were asked to provide their data collection methods. In Figure 1, it is evident that pre-tests and post-tests and student work samples formed the basis of the students' data.

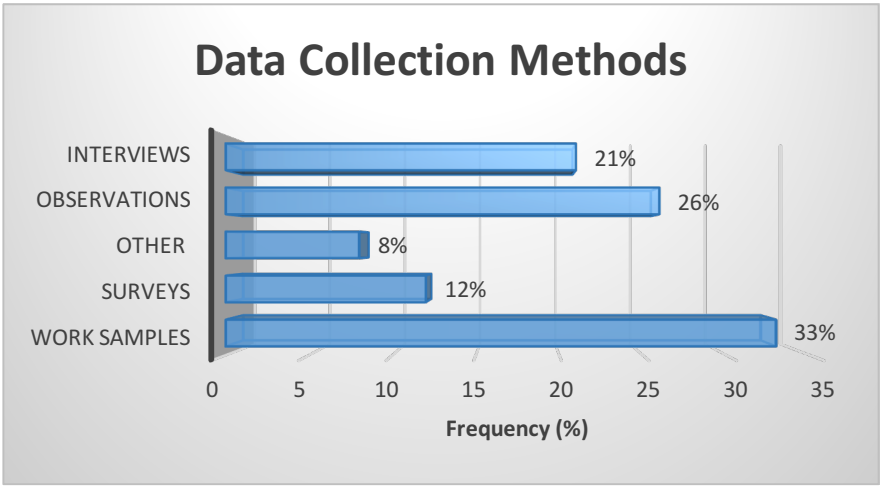

Figure 1. Data collection methods.

The aim of items eight and nine was to elicit how students established whether or not their measures were effective using data that they had collected. In item eight participants were asked: How did you analyse your data? (i.e., What did you do to make sense of your data?) The responses for this item demonstrate that 47 % (n=14) of students used comparative analysis between test results or other student work samples. Twenty percent (n=6) of PST provided descriptive responses about analysing data into graphs and tables and noted that it was related to the visualisation of the data. Twenty percent (n=6) indicated that they used document analysis of student work. Thirteen percent (n=4) students either provided no responses or unrelated responses. The PST were asked in item nine how they represented their research findings in their action research journal (i.e., How did you show what you found?). This was a multiple-choice question. As PST were expected to collect multiple sources of data, we assumed that they would provide multiple responses to this item. In some instances, three to four responses were provided. Results are provided as percentages. Figure 2. Displays the types of data representation methods used by the PST. The most frequent means of presenting the results was text description.

In item ten, PST were asked why they selected these methods of representation. The responses fell into two categories. Sixteen PST (53%) indicated that it was the most appropriate or effective way to show their results. Twelve of the PST (40%) indicated that representing the data as they did was the easiest was to do so. One pre-service teacher did not respond and one PST provided an invalid response. What is evident here is that the pre-service teachers could identify procedures to collect and analyse data in order to demonstrate POOL. From the different measures used it is evident that they selected strategies to answer their questions; however, what is not evident is whether or not they actually selected valid measures or presented their data appropriately. It can be put forward that PST were able to make basic choices regarding the collection and visualisation of their data. However, this is a self-reporting survey, and PST may not have the capacity to unpack their choices.

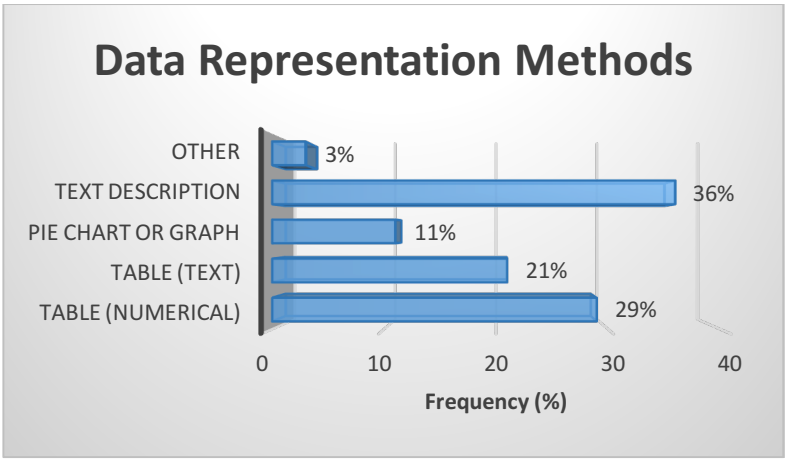

Figure 2. Types of data representation in the action research journal.

The second Research Question asked: How do design choices impact upon understandings of learning and teaching data? A thematic analysis of the journal articles provides examples of how the PST represented their findings. Here we looked at how PST presented their own findings. Only a preliminary analysis of the documents has been undertaken at this stage, and the results presented here are simplistic. What we found was that PST used a range of basic visualisations, such as graphs and tables. Pie charts, although they were not raised in the training, were frequently used. Figure 3 provides an example of a student pie chart. Note that there are no data labels on the chart.

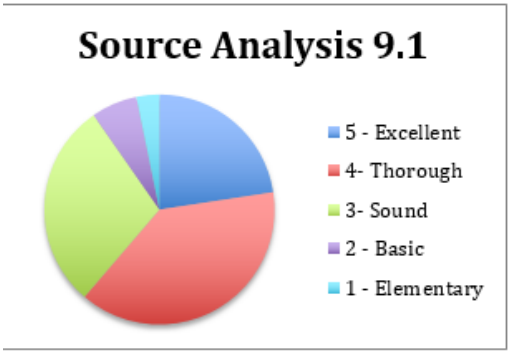

Figure 3. PST data visualisation (pie chart).

The PST also tracked individual students or student cohorts across test or exam scores in order to demonstrate learning gains and to demonstrate POOL using line graphs. Again these were not covered in the training. For example, Figure 4 provides an example of student progress across the 10-week intervention.

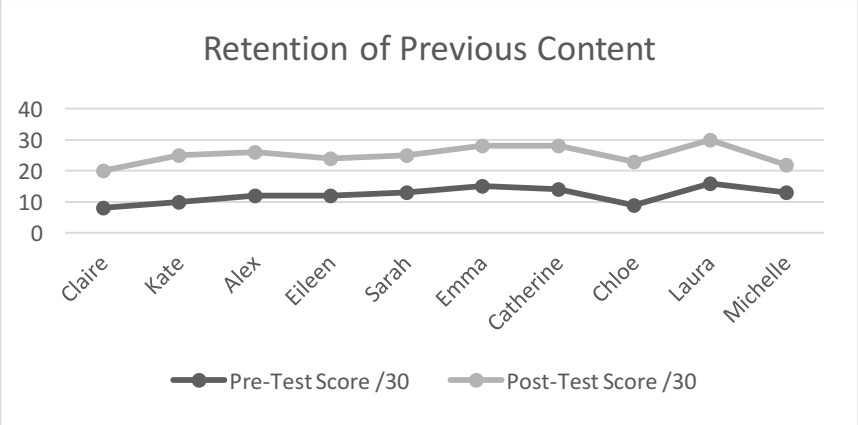

Figure 4. PST data visualisation (line graph).

Some students put forward more complex visualisations, such as box and whisker diagrams. No students used R to develop their visualisations, despite the training. What we argue here is that the students had a basic understanding of how to collect and analyse data, and they were able to use this information to make changes to their learning and teaching strategies. So in this respect, the intervention worked in that the PST could ascertain a limitation or challenge, implement a learning strategy and teaching initiative, and report upon their findings. However, the selected visualisations were basic or simply not appropriate for the purpose. What needs more work is their development of a more nuanced understanding of how to represent the data meaningfully.

Conclusions

While all of the PST successfully completed the action research journal, there was a naivety in the representations of the data. It is acknowledged that this is only the preliminary analysis of the first phase of the study. Currently, further research is being undertaken that has increased the PST's exposure to the explicit teaching of the requisite data literacy skills. In the most recent study, the PST were given explicit instruction in the appropriateness of different visualisations. It is hoped that through increased exposure to explicit instruction that the PST may develop a deeper understanding of how to represent and use learning and teaching data to inform their classroom decisions.

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