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Reflections on Journaling: An Initiative to Support Pre-service Mathematics and Science Teachers

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Abstract: In this article the authors present two different ways in which journaling has been utilised with final year pre-service teacher students (PSTs) in their primary/middle science and mathematics pathway course. Pedagogical practices that model effective teaching and learning in a tertiary setting are an integral component of this course. As teacher educators exploring ways to develop our practices, we introduced journaling as a teaching and learning tool. The first results section of this article focuses on the journaling experiences of PSTs, including the different ways they chose to engage with journaling and factors contributing to their engagement or disengagement. The second presents four case studies of PSTs who used journaling as part of their action research and/or in their final teaching practice. The findings highlight a number of different approaches to journaling which support graduate and pre-service teachers in their endeavours to be reflective teachers of mathematics and science.

Introduction

There is much research that suggests that recording and reflecting on one’s thoughts, when teaching, can impact positively on students’ learning outcomes and that this is of particular importance for pre-service teachers (PSTs) (Darling-Hammond & Snyder, 2000; Valli, 1993; Zeichner, 1996). Judd (2013), for example, suggests that reflecting on and reviewing learning events can enhance learning outcomes, while Farrell (2007) and Lanigan (2007) infer that reflective writing ensures that students become more aware of the ways in which they learn. Documenting critical moments, or strategies that did or did not work, or puzzling over why things unfolded as they did ensures that PST pedagogical practices continue to evolve (Goodell, 2006). Hence, the professional experience courses that PSTs undertake (across most universities) typically include daily reflection on teaching and learning as a compulsory requirement. Much research tends to focus on journaling or reflecting as a writing process and suggests that journal writing, biographies and reflective essays are the most frequently used reflective tasks (Hatton & Smith, 1995).

Van de Walle, Karp, Bay-Williams & Brass (2019, p. 101) encourage PSTs to make written communications a regular part of doing mathematics, and suggest that journals are a place to monitor their conceptual understandings, problem-solving outcomes, questions that are unanswered and feelings about aspects of mathematics. Reys et al. (2012, p. 101) also support the use of journals, encouraging PSTs to write about questions such as *What am I puzzled about? What mistakes do I make and why?* Similarly, in science it is common to read about students’ use of both notebooks and journals to document wonderings and curiosities, emulating the work of scientists in the field throughout history. A recent inclusion in the

Primary Connections Series for teaching primary science is a student science journal for several units in each year level (Australian Academy of Science, 2017).

Whilst reflection is an essential tool in practicum experiences, and PSTs are encouraged to journal as part of this reflection, this was the first time we opted to introduce it in the science and mathematics class leading up to the practicum. The aim of this study is to investigate the process of journaling as a means of supporting PSTs, with a particular focus on their development as primary/middle teachers of mathematics and/or science. For this work, technically speaking, we see journaling as part of the re-count family (see Derewianka & Jones, 2016) and as such our interpretation of journaling includes a range of reflective practices. This article reports on the findings of this small classroom inquiry project and the impact it had on our final year science and mathematics PSTs both in the university course and when teaching in their final placement.

Journaling in Mathematics and Science Education

Feedback-supported journaling promotes reflective thinking and achievement, with a positive effect on metacognitive awareness, feelings and motivation (Cengiz, Karataş, & Yadigaroglu, 2014; Cengiz & Karatas, 2015). Reflective journals have the capacity to increase the complexity of PSTs' reflection, moving beyond the level of technical rationality (Kaminski, 2003). Loughran (2002) discusses how reflection continually emerges as a suggested way of helping practitioners to better understand what they know and do in science teaching and learning as they develop their knowledge of practice. More recently, Oner and Adadan (2011) discuss the use of teaching portfolios as effective tools in PST reflection. While on the surface this may appear to be a different form of recording or reflecting, a further review of literature on teacher portfolios suggests that journaling forms a large part of this recording. For example, Wade and Yarbrough (1996, p. 77) note that, even though it was not a requirement, many of the PSTs in their study kept a journal which the researchers believe was "an important vehicle for considering their experiences over time and developing new understandings and appreciations".

McNaught's (2010) work in mathematics education suggests that autobiographical journals enable PSTs to reflect on, make sense of and share past experiences of learning mathematics. Journal writing can promote positive change in PSTs' attitudes and beliefs about science and science teaching (Bell, 2001) and mathematics and mathematics teaching, increasing their confidence and their willingness to take risks (Kaminski, 2003; McNaught, 2010). Through journaling, primary school PSTs came to believe that science could be fun and should be an important part of young students' learning (Bell, 2001). Journaling has also been found to have a therapeutic effect on the emotional aspects of learning mathematics, increase knowledge of content, and improve learning and problem-solving skills (Borasi & Rose, 1989).

Reflective journal writing can promote self-regulated learning strategies, including self-reflection (Al-Rawahi & Al-Balushi, 2015) and the dialogical aspect of this can result in more individualised teaching and a more supportive class atmosphere (Borasi & Rose, 1989). Therefore, journaling can be used as a differentiation strategy in itself or indeed point to more effective/targeted approaches to differentiation. For example, Ehlers (2015) highlights how asynchronous online journaling in science can engage students and enable them to make explicit prior knowledge about a topic, construct new information and promote self-regulated learning. Additionally, Glogger et al. (2012) suggest that learning journals are a useful and innovative method for assessing student learning strategies in mathematics in middle school. Journaling can encourage regular articulation of thinking and in turn can support students'

procedural knowledge, conceptual understanding and mathematical communication (Jurdak & Zein, 1998). Similarly, Page and Clarke (2014) found journaling in mathematics provided an opportunity for primary teachers to include and value students' feelings, beliefs and attitudes. This in turn meant the students felt more valued and cared for. To improve the reflectivity of journals, several studies suggest that both school students (Glogger et al., 2012) and PSTs (Cengiz et al., 2014) would benefit from more comprehensive training in journal writing. To assist primary school students in this regard, Page and Clarke (2014) advocate using brainstorming to build a vocabulary of mathematical reflection, sentence starters, continuums to represent feelings about mathematics, and questions to prompt student reflection.

Context

PSTs in their fourth and final year of a primary/middle undergraduate teaching degree at our university are required to complete a professional pathway in their specialisation learning area. This professional pathway is a semester course that precedes their final placement. The aim of the course is to ensure that they are more than *classroom ready*, in our case, to teach both science and mathematics either as a generalist or science/STEM NIT (Non-Instruction Time teacher) in Years 3–7, or as a specialist in middle school (Years 8/9). While the PSTs have had previous curriculum courses which focus on pedagogy, this pathway course extends this by encouraging the PSTs to push boundaries and think outside the box – attempting in many ways to reflect Kemmis and Edwards-Groves' (2018) ideas around 'saying, doing and relating', which are the core components of practices. Such pedagogical practices include a ten-day voluntary place-based experience in an urban ecological setting (Borgelt et al., 2009; Tytler, Barazza, & Paige, 2011), undertaking an act of 'green' (aka a pledge) (Paige, 2016), researching the history and philosophy of prominent scientists and mathematicians to contribute to a timeline, planning interdisciplinary units of work, a focus on Indigenous perspectives (O'Keeffe, Paige, & Osborne, 2018) and constructing Slowmations focusing on either a science or mathematics concept (Paige, Bentley, & Dobson, 2016).

We first introduced the idea of journaling in 2015 after one of us had found an auto-ethnographical approach to documenting ideas, short courses, research literature and inspirational insights during a previous sabbatical helpful in her reflective process. The author's journal, which contains written notes, newspaper clippings, ticket butts, photographs and artefacts (e.g. a pressed leaf from Isaac Newton's apple tree), was a visual representation of her key learning during this sabbatical. Drawing inspiration from this, the author shared this example of journaling, among others, in the first workshop with the PSTs – highlighting how journaling can provide an opportunity to document learning using a variety of creative processes. There was a clear emphasis here on how choosing one's own creative preferences can support an individual to reflect and record in a manner which is authentic to them. While the PSTs had previous experience with reflecting, 'journaling' was a new experience to all of them. When introducing journaling to the cohort we indicated that this was our classroom inquiry (they would be undertaking a critical practitioner inquiry themselves in their final year teaching placement) and we would be monitoring the outcome (Wrench & Paige, 2019). We chose not to make journaling part of the course assessment, knowing that grading journals can often defeat the purpose of open and honest reflection, with 'journalers' writing for the grader/reader rather than themselves (Hatton & Smith, 1995; Van de Walle et al., 2019). Hence, to ensure an authentic journaling experience we included journaling as a voluntary extra task. Our wish was for the students to record and reflect on their journeys

with mathematics and science in a way that worked for them. We provided each student a sketchbook, irrespective of their journaling decisions (e.g. even those who did not plan on journaling and those who planned on journaling electronically still each received a sketchbook). We also stressed that recording was not limited to hard-copy methods and that electronic/digital options and oral recordings were also possible and encouraged. At monthly intervals we allocated time in workshops for PSTs to share recent entries, to inspire/remind peers and to help to keep momentum.

Method

This study focuses on understanding fourth year students' experiences with journaling as a reflection and pedagogical tool. The aim of this study is to investigate the process of journaling as a means of supporting PST development, and to understand how and why they chose to engage or not. The questions guiding this research are:

- What are the factors that contribute to PST engagement or disengagement with journaling?
- In what ways do PSTs engage with their journals and how does this contribute to their subject knowledge/confidence?
- What do pre-service teachers perceive are the benefits or drawbacks of journaling?

The students in the sample are all final year primary/middle pre-service teachers who have chosen a pathway course in mathematics and science; hence this article presents a case study of their experiences. All students in this cohort were encouraged to engage with journaling from week 1 of their pathway course and all were then invited (during the final lecture in week 13) to volunteer to participate in various ways in the study. The study comprised two key stages of parallel phases of data collection. Descriptive analysis of the quantitative data was analysed using SPSS, while qualitative data was coded for key themes using NVivo.

- In the first phase of data collection the cohort was invited to participate in an anonymous qualitative survey; 21 of the cohort of 27 completed this questionnaire. The questionnaire comprised 14 questions, the first two of which were related to gender and their chosen areas of study (all primary/middle PSTs have the option of choosing two learning areas as minors). Questions 3 to 5 related to student engagement in general and were adapted from the 2011 Australasian Survey of Student Engagement (AUSSE) (developed by ACER, n.d.), while questions 6 to 14 focused entirely on journaling. The aim of this questionnaire was to investigate how the PSTs engaged with their journals and their reasons for doing so; hence this questionnaire included both open and closed questions to provide an opportunity for the students to expand/elaborate on their responses and discuss the potential advantages/drawbacks of journaling as a pedagogical tool. Illustrative examples of students' entries that powerfully represent reflective practices are included and discussed in the findings.
- The second phase of this study involved case study participants' reflections and experiences of using journals in their role as teachers. Four PSTs chose to complete their inquiry action research project on their use of journaling as a teacher and submitted a reflection on their experiences (Wrench & Paige, 2019).

Findings from Phase One: Survey Data

Of the sample of 21 students who participated in this study, 16 were female and 5 were male. Mathematics accounted for 18 of the 42 learning areas noted (they each study two learning areas) and science accounted for 12. Nine of the students had both mathematics and science as their two learning areas.

Student Engagement in General: Extract from the Australasian Survey of Student Engagement (AUSSE)

The participants were asked to estimate how often they had engaged with various aspects of preparing for or extending their enjoyment with their studies. They were asked to select one of four options which best describes how often they had done each of the activities listed in Table 1 throughout the study period: never (1), sometimes (2), often (3), very often (4). Each answer option was coded numerically (from 1–4) and this data is presented in Table 1 below.

	n	Range	Mean	SD
Asked questions or contributed to discussions in class or online	21	[1,4]	2.90	0.889
Sought advice from academic staff	21	[1,4]	2.67	0.856
Prepared two or more drafts of an assignment before handing it in	21	[1,4]	2.48	1.030
Worked on an essay or assignment that required integrating ideas or information from various sources	21	[2,4]	3.48	0.680
Came to class having completed readings or assignments	21	[2,4]	3.52	0.602
Kept up to date with your studies	21	[2,4]	3.57	0.598
Participated in a community-based project (e.g. volunteering) as part of your study	21	[2,4]	2.95	0.740
Worked harder than you thought you could to meet a lecturer's standards or expectations	21	[2,4]	2.90	0.889
Discussed ideas from your readings or classes with others outside class (e.g. students, family members, co-workers, etc.)	21	[1,4]	2.67	0.856

Table 1: Participant Summary of their Engagement with and Preparation for Study

From Table 1, it is clear that all participants felt they worked hard to meet their lecturers' expectations and they all participated in some volunteering (which was part of the rich task requirements set out in this course). The three academic activities that this cohort of students are most likely to do (mean scores > 3) are: integrating their ideas, reading to prepare for class and/or assignments and keeping up to date with their studies. Yet some students indicated that they never asked questions or contributed to discussions, sought advice from academic staff, prepared two or more drafts of an assignment before handing it in, nor discussed ideas from readings or classes with others outside of class.

The participants were also asked to indicate how much reading and writing they had done throughout the study period and about additional experiences they might have had including attending art exhibitions and participating in physical activities (see Table 2). The potential responses for this were none, 1 to 4, 5 to 10, 11 to 20, and more than 20. These answer options were coded from 1 to 5 giving the following data (Table 2). The data indicates that the things these participants are least likely to do are write for their own personal enjoyment or academic enrichment (11 participants indicated they had never done this) and attend art exhibitions or performances of some kind. In contrast, the kinds of activities that the PSTs are more likely to engage with are those which are required in their university courses such as reading textbooks and completing written assignments.

	n	Range	Mean	SD
Number of assigned textbooks, books or book-length packs of subject readings	20	[1,5]	3.25	3.25
Number of books read on your own (not assigned) for personal enjoyment or academic enrichment.	21	[1,5]	2.29	2.29
Number of written assignments.	21	[2,4]	3.33	3.33
Number of writing activities on your own (not assigned) for personal enjoyment or academic enrichment.	21	[1,4]	1.76	1.76

Table 2: Participant Summary of Reading, Writing and Additional Activities

Journaling

Of the 21 students who participated in the survey, fifteen indicated that they engaged with journaling in some way. However, as evident in Table 3, what they deemed ‘engaged with’ varied greatly. Most participants opted to engage with a hard-copy version of a journal (13 out of 15). This is likely to be because we provided a hard-copy book for journaling to all of the 27 PSTs. Of the 15 participants, only one PST kept a journal by using only written text, ten used a combination of writing and sketching, while four others mainly used text and added in artefacts and/or print-outs (examples are provided in Figures 2,3 and 4).

	No. of students	Digital journal	Hard-copy journal	Preferred method of recording
More than twice a week	0	-	-	-
Approximately once a week	3	0	3	Writing & sketching/drawing (2) Writing and adding in artefacts/cut-outs etc. (1)
Approximately once every two weeks	4	1	3	Writing & sketching/drawing (3) Writing and adding in artefacts/cut-outs etc. (1)
Approximately once a month	1	0	1	Writing & sketching/drawing (1)
Only at the start of the course	7	1	6	Writing & sketching/drawing (4) Writing and adding in artefacts/cut-outs etc. (1) Only writing (1)

Table 3: Frequency of Engagement with Journaling

The wordle in Figure 1 gives an overview of all of the responses participants gave in regard to what they recorded in their journals. Notes, information, class activities and pledge recordings were most common.

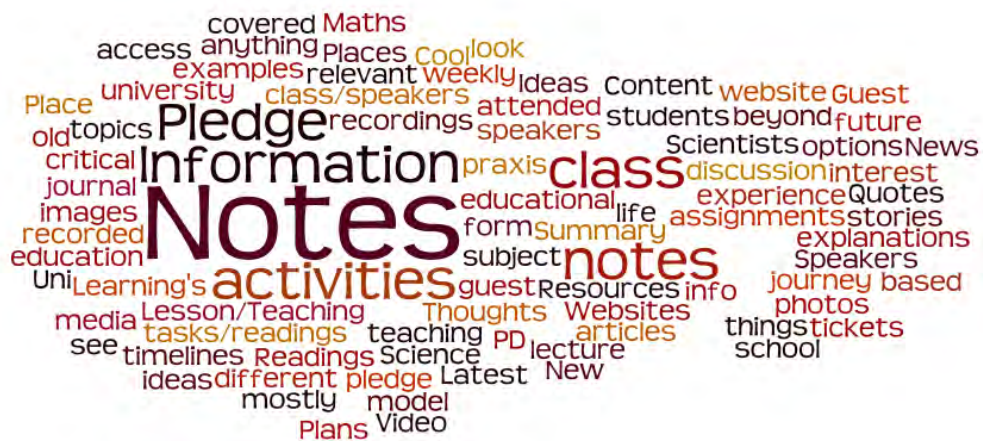


Figure 1: Overview of the Types of Things the Participants Chose to Record in their Journals

When asked to explain why they did or did not choose to engage with journaling, the six who did not journal gave responses ranging from they felt it was extra work, to they did not have enough time, to it was not their preferred way of documenting/learning. One female participant stated: *“Unfortunately, I just don’t learn that way. To try to complete a journal on top of the requirements for all of my other courses was just too much stress and pressure to put on myself for something that I didn’t believe I’d learn from.”*

Six of the seven participants who only used their journal at the start of the course made reference to time, noting that as the demands of the study period increased something had to give and, as this was not part of the assessment, they did not continue recording in their journals. However, two of the participants added that they saw value in the use of journals but it just did not work for them. One female participant added: *“I didn’t feel I had done anything exciting enough to record in it. I did have more that I intended to put in from staff training and newspapers but would forget to cut it out/stick it in before discarded.”* The remaining seven participants engaged with their journals either once a week or once a fortnight. They noted that they found their journals helpful to record class notes in *“less traditional ways”*, such as using mind maps and drawing, recording ideas and activities, or additional interests such as life stories of historians. One female participant noted that she *“found it as an engaging way to reflect on readings, videos and guest speakers”*.

The most preferred method of recording was a combination of writing and drawing (see Table 3). The reasons given for this were mostly related to the participants liking drawing and/or being good at drawing. For example, some PSTs opted to use summary notes, as in Figure 2 below. The left-hand side of Figure 2 is one student’s recordings following a lecture presented by three experts on culturally responsive pedagogies, while the right-hand side is an example of a summary mind map created by a student towards the end of the pathway course.

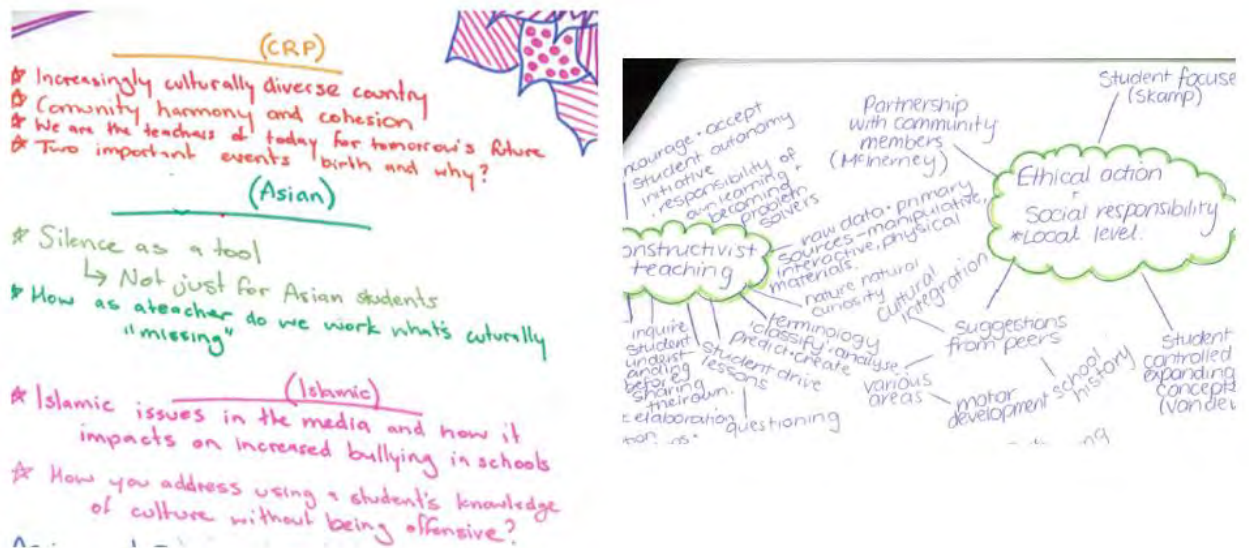


Figure 2: Extract from PSTs’ Journals – Written Examples

Others opted to include actual photographs of tasks from class (Figure 3 left hand side) or artefacts gathered as part of class tasks (Figure 3 right hand side). Those who collected and glued in artefacts made comments such as this: “I am not very artistic. Collecting objects from activities we have done allows me to come back and visually see the task or find a written explanation of how it was undertaken.”

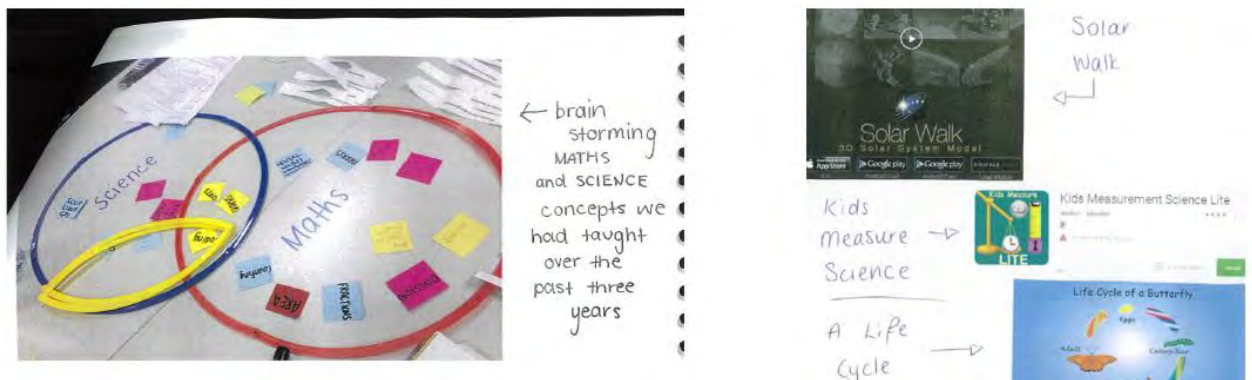


Figure 3: Extract from PSTs’ Journals – Examples of Use of Photographs and Print-Outs/Artefacts

The students who identified as creative and artistic were more likely to include drawings as the main recording method or in conjunction with their written notes (Figure 4). The left-hand side of Figure 4 is an extract following a task on paint mixing as a context for understanding ratios, while the right-hand side is a student’s summary notes of their findings as part of researching a historical mathematician or scientist.

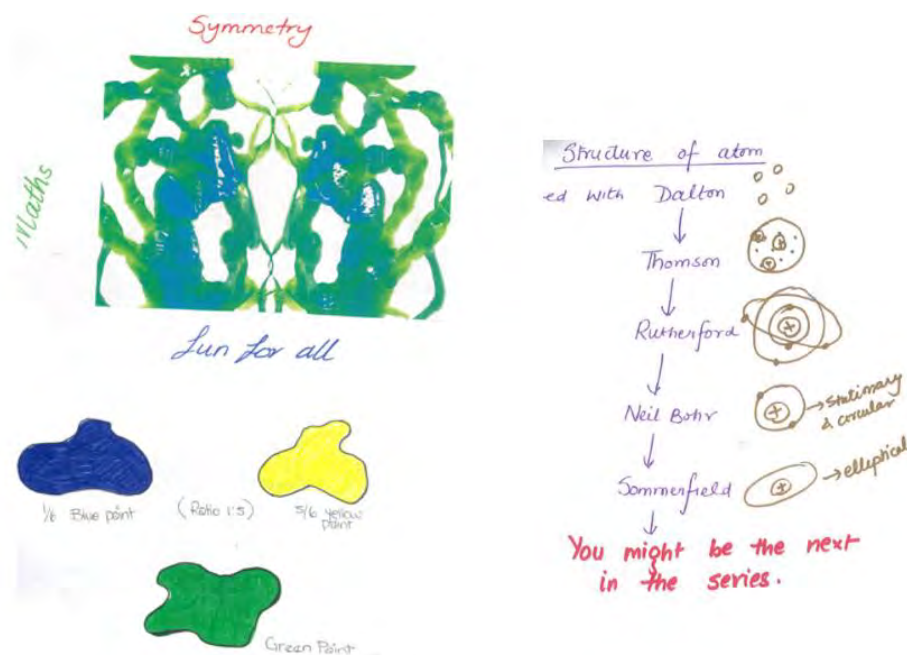


Figure 4: Extract from PSTs' Journals – Examples of Use of Drawings

Ten of the participants who journaled felt they gained something from the process. The reasons for this included that their journals helped them to reflect on what they learned and how they could use these ideas in their future teaching, their journals helped them to record their additional research and reading, and it helped give them insights into how useful journaling could be. One participant was 'unsure' whether they had gained anything from the process but they, along with the four participants who felt that they had not gained anything all, noted that they felt they had not fully engaged with the concept of journaling and may have gained more from the process if they had.

All 21 participants were asked about the advantages and disadvantages of journaling as a learning activity for mathematics and science in general. All 21 participants felt there were advantages to journaling. The most common response was that journaling would help students to reflect on their own learning and progress (9 participants; only 15 responded to this open-response question). One participant added that they felt it would work with younger years only. Only six participants felt there were no disadvantages of using journaling as a learning activity – each of these were participants who had engaged with journaling. The lists of advantages and disadvantages identified by the participants are provided in Table 4.

Advantages	No. of students	Disadvantages	No. of students
Reflection and tracking of learning	9	Just another thing to complete	5
Freedom of self-expression	2	Time	4
Potential source of inspiration	1	Not for everyone/may not suit students' learning approach	4
Source of good ideas and where to find things	1	May include personal information	1
Note taking	1	Students may not engage if they don't feel strongly about it	1
For younger years only	1		

Table 4: Participants' Perceptions of the Advantages and Disadvantages of Using Journaling as a Learning Activity in Mathematics and Science

The participants were also asked if they would use journaling in their own teaching, either on their upcoming final teaching placement or when they were teaching in the following year. Seventeen of the participants indicated that they would use journaling as part of their future teaching, while the four others said they would consider it. Six of the participants who might use journaling as a learning activity indicated that it would depend on the student group and if they felt it would work for them. Five participants cautioned they were aware they would need to ensure they guided students' use of journaling carefully, while four others felt they would use journaling as part of either informal or formal assessment strategies.

The final question in the survey asked the participants whether they thought we should include journaling with the following year's cohort of students. We felt this was important to include as we strongly believe in student voice. Twenty of the 21 participants responded to this question. Five participants felt we should include it. Each of these five participants had engaged with journaling themselves throughout the study period. While one of these participants did not think we should change how we used or introduced the journals in any way, one felt they should be part of a graded assignment, another felt there should be more time in class to work on them, while the remaining two participants felt they would have benefited from a more structured approach.

Eight participants, however, felt we should not include them in the course again (five of whom had not engaged with the journals at all, citing time as the issue). One of these eight participants felt that if they were to be used again it should be as part of a graded assignment, while two others felt more time should be given in class. The others did not provide any suggestions. The remaining seven participants were unsure about whether we should continue to encourage the use of journals, suggesting that they should either be part of graded assessment (1) or optional (6), which they currently were.

Findings from Phase Two: Four PST Case Study Reflections

As the second phase of this study, we invited the PSTs to share the different ways they used journaling in their final year teaching placement. For their practitioner inquiry project during their placement the PSTs are required to inquire into a particular pedagogical approach in their own teaching. They are supported and guided in this project by a member of the teaching team. The next section presents four case study reflections from the PSTs who chose to focus on journals as part of their inquiry project. The reflections provided were written by each of the PSTs and the italics used within these reflections indicate quotations from the PST students' journals or feedback. All names used are pseudonyms.

Case Study 1: Vincent

Vincent's learning areas were mathematics and health and PE. Vincent undertook his final placement at a large R–12 school. He chose to implement journaling to investigate how it could be used to support student learning in mathematics. Vincent's summary reflection comment was that using journals would be *“more realistic in a primary school setting where there is more teacher and student interaction”*.

Vincent's Reflection

The focus of my PIP was to determine whether the use of journals in mathematics would assist with content knowledge and retention. Five students were selected at random to complete these journals. Of these five students, four engaged with the idea and completed some form of journal throughout the unit of work. All five participants believed that journals could be/were useful. N, who did not add much to her journal, even stated that "Yes it would be helpful; it can help you remember things better if we write them down". The students who did engage made comments such as "it let me explain concepts to myself" (C); journals help us to "put [our] thoughts on paper" (Ni) and "look back" (J) on "what we learnt in class" (G).

There were many constraints to implementing journals throughout the unit. These were:

- *Firstly, not being consistent with reminding students to fill out the journals, this was a major issue as there were time constraints with trying to get through content and activities as well as allowing time to practice. Plus, timetables only allow teachers to see students a few times a week as well.*
- *This was a very small sample of students and assessments. Hence, the range of data is very small and so no real obvious trends within the students' results.*
- *Other limitations include external factors such as students not being in class therefore missing out time to fill out journals and on new content.*

Case Study 2: Eva

Eva's learning areas were mathematics and health and PE. She completed her final placement in a Year 3/4 class in a dynamic, low socio-economic-status primary school.

Eva's Reflection

My PIP was focused around Professional Practice: Standard 5 (Assess, provide feedback and report on student learning). The school where I completed my final placement is a school built upon the Walker Learning Approach¹. I found their way of monitoring student progress and 'checking in' very helpful, particularly coming into the classroom not knowing the students. For my PIP I have added to this method of monitoring progression by introducing a focus student journal into both of the Year 3/4 classrooms. Within this focus student journal, students had the opportunity to self-reflect on their learning and were encouraged to reflect on tasks they have found challenging or need to be expanded. In their journals students have discussed the topics they are most interested in, areas they wish to be more challenged in, and goals they have set for themselves that need teacher assistance. Two examples of student reflections are: "I need a challenge in Maths and English, it's mostly when I finish an activity, the level is pretty good but it could be more challenging" (Student A) and "I can improve

¹ The Walker Learning Approach was one of Australia's first play and project-based pedagogies. It focuses on intentional teaching and learning approach, that is cross disciplinary. More information on this approach can be found here; <https://earlylife.com.au/about-walker-learning/>

my maths. I'm in the middle group. I want to be in the highest maths group" (Student B).

As using a journal was a new idea, not all the students have taken the time to reflect in the journal. They have, however, all showed great excitement that they have ownership of a class journal. Reading these reflections has enabled myself and my mentors to begin to reflect on our teaching approaches and amend content in lessons to enable students to be successful in a range of areas. This journal will continue to be available during Term 4 to then be shared with their teacher the following year.

As well as the class journal, I selected a small group of students (with the assistance of my mentor teachers) to complete their own personal journals. The students selected are those students who tend to finish work before the set time and therefore are usually left with either nothing to do, or on-the-spot extra tasks. These journals are 'free-range', meaning students can write about anything. For example, they can practice drawing, handwriting, maths – anything they wish. Prior to beginning this personal journal, I took time to sit with these students and discuss some of possible entries they could include. All students were excited and eager to get started.

I have since looked through their journals on a number of occasions. I am mindful not to correct things like grammar, spelling and structure as these are the personal reflections of the students and are written for themselves, not for assessment. My hope for these journals is that students continue to use them throughout the holidays and in term 4 to share experiences that they deem to be important in their lives. In addition, by regularly 'checking in' it is my hope that tasks can be modified to further challenge their learning prior to lessons. It has been great to see the enthusiasm students have towards having the chance to reflect on their own learning. In the future, when I have my own classroom, I would implement some of the methods used in a Walker Learning setting, as well as my own methods of journaling from the beginning of the year. The student insights that have been shared indicate that giving more responsibility (to the students) for their learning develops their ability to self-manage.

Case Study 3: Andy

Andy's learning areas were mathematics and food and textiles technologies. Andy undertook her final placement in a rural primary school. She implemented mathematical journaling with a Year 6 and 7 class. Over the four weeks, she had the opportunity to elicit students' attitudes towards mathematics.

Andy's Reflection

In the first journal writing experience I shared the purpose of the journals with the class to ensure they would write meaningful reflections. The class respected this and the confidentiality of their journals. This lesson set the scene for future writing experiences. Mathematical journaling was implemented with two variations of writing prompts: (i) affective and (ii) mathematical (see Table 5 below). Affective stimuli elicited thought and expression while mathematical prompts provided a window to student understanding of the topic (Williams & Wynne, 2000, pp. 132–133). This ensured pupils had the opportunity to

communicate their mathematical knowledge, attitude and feelings. The class had an average of two out of the four mathematics lessons per week with allocated time to record in their journals. With a combination of writing prompts, students remained engaged with the experience without being bored of repeating the same task. This meant that students did not write in them too often to feel as if it were a chore. Table 5 provides an example of prompts used as a warm up to the lessons or a reflection to close the lesson. The journal prompts were typically displayed on the interactive whiteboard and sometimes were pasted directly into student journals and answered.

Affective prompts	Mathematical prompts
<ul style="list-style-type: none"> • What do you enjoy about mathematics? • Mathematics is tricky when ... • What makes a good teacher? • What makes a good student? • Discuss whether you have enjoyed journal writing in mathematics and explain. • Which journal writing did you enjoy the most and why? • Which journal writing did you least enjoy, and why? 	<ul style="list-style-type: none"> • What is the ratio? • Explain what ratio is and give an example. • Find the simplest form of this ratio. • Describe what rule the pattern follows. • Write a formula for this sequence. • Use your formula and find the number of matchsticks in the 23rd term.

Table 5: Examples of the Affective and Mathematical Journal Prompts Used

Reading these responses gave greater insight into student preferences and how to accommodate different learners. For example, many students responded that they enjoy a challenge but do not always get the opportunity to stretch their thinking. Students appreciated the connections between what they recorded in their journals and the changes made to mathematics lessons. They were more engaged knowing that I was taking their perspectives into consideration.

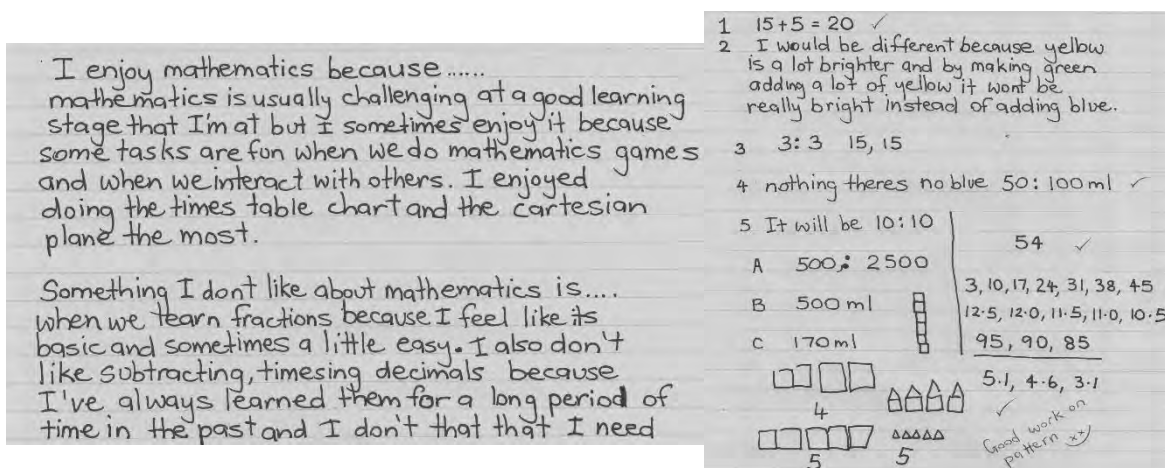


Figure 5: Examples of Student Journals. LHS: Reflection on Affective Prompts; RHS: Reflection on Mathematical Prompts

The mathematical journal prompts allowed students to demonstrate their mathematical thinking and explain their reasoning. This provided students and the teachers with additional insight (see example in Figure 5 RHS). Although it was a mathematical prompt that the learners responded to, this student articulated their thoughts in their journal. The student used an illustration, which meant I could see how they were thinking about ratio. On reflection, if I was to implement mathematical journaling again I would develop a system where students share their books with me if they have recorded a question or something that they want to share with me – as opposed to collecting all journals after every session. Additionally, during journal writing times I would share examples of my own and with student permission I would share student journal entries with the class. This would allow the others to see an example of how students have recorded their mathematical thinking.

Case Study 4: Beth's

Beth's learning areas were mathematics and science. She undertook her final placement as a non-instructional teacher (NIT) for science in a primary school. In this role she taught all classes (R–7) science for one hour each week. As she did not have access to students' work/class books she introduced the idea of journals for each year level that she worked with. She used the opportunity to create teacher-led science journals in order to track each class's learning. Beth believes that "*integrating science journals into[her] teaching has greatly benefitted and improved [her] teaching practice*".

Beth's Reflection

I was working with 14 separate classes for this placement. Each class is unique in their own way and therefore no class constructed the same scientific investigation questions (despite working on the same content), had the same scientific discussions, or completed the same set of work in the same set time. I ended up creating four separate A3-sized journals for 14 individual classrooms that ranged in year levels from reception to Year 7. These journals benefitted students in that they got visual cues of what they learnt last lesson (see Figure 6). This was very helpful as lessons with me were typically only once a week. The three samples all focus on the topic of weather. The first, with early years students, documents weather words and the five senses; the second and third examples focus on the different phases of the water cycle, scientific methods and recording student questions.

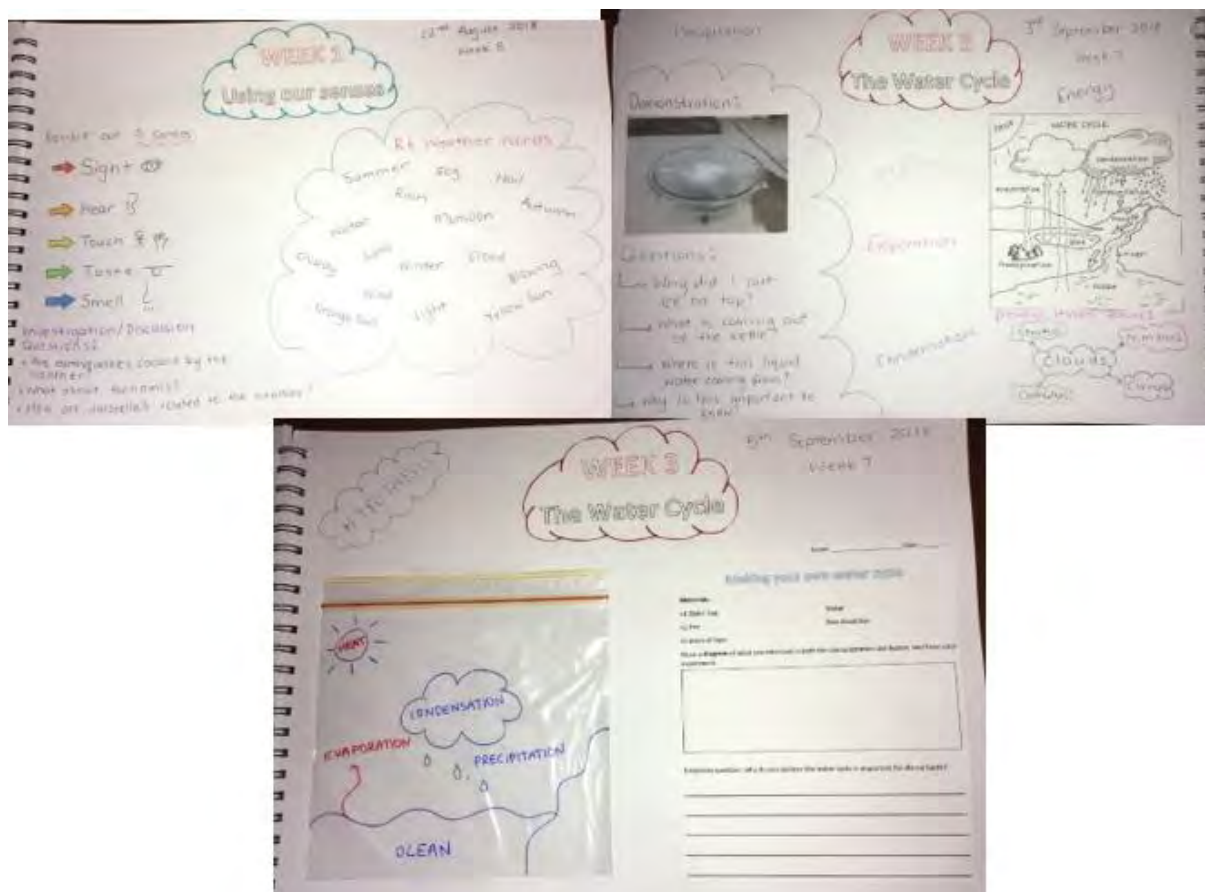


Figure 6: Examples of Extracts from Student Journals

Many of my students also had siblings in the school and loved not only engaging in their classroom science journal, but also finding out what their siblings do in their science lessons and comparing how the content was similar and how it was different. What surprised students was that, whilst the topic of the week, for example cloud types, was the same, the content I was investigating with the students varied from unit to unit. I found my older students were then teaching their younger siblings concepts I had covered in my science lessons, so the investigation questions my younger students were developing were becoming more in-depth and had a deeper level of scientific understanding behind it. The science journals enabled me to make some comparable judgements between the different classes in a particular unit, and discuss with their classroom teacher (many classrooms also had PSTs) either how they could improve their efficiency in completing the work as a class, or how we can integrate a specific science topic into their classroom teaching to deepen the understanding and to begin to develop a small transdisciplinary unit. When given the opportunity to have my own classroom, I will be doing journaling again as not only did it benefit the student learning as they got a hands-on resource that documents what they were learning in science by breaking down the lesson, it also supported me in reflecting on each class to understand where to go next.

Discussion

As evident in the phase one data collection, there was a mixed response to the uptake of journaling but also in how useful PSTs found journaling. Not surprisingly, the cohort identified they are more focused on completing required assignments and readings than additional work (see Table 1) and they are less likely to engage with writing for their own enjoyment in comparison to reading for enjoyment and reading or writing for university work. Therefore, one could expect a low rate of uptake for optional journaling, meaning an engagement rate of 15 out of 21 was relatively good. These 15 participants can be grouped into three groups: 1) those who chose to engage, 2) those who chose to engage only at the start, and 3) those who did not engage at all. Group 3 all referred to the issue of time and seeing this as an 'add-on'. Surprisingly, 5 (of 6) of this group suggested we should include journaling with the next year's cohort. Only 3 (out of 21) suggested we should add journaling as an assessment component, which in some ways reflects Van de Walle et al.'s (2013) and Hatton and Smith's (1995) warnings about not grading journals. In general, the PSTs supported our decision to keep journaling voluntary. They did however think that journaling could be more integrated into class time, creating time for them to engage rather than leaving it up to them to do so.

Our intentions align with Wade and Yarbrough's (1996) ideas that journaling over time would support PSTs to develop and extend their appreciation of the possibilities available to them to extend their pedagogical approaches and ideas around teaching in mathematics and science. The open approach taken to journaling enabled PSTs to work in whatever methods/approaches worked best for them. The most preferred method chosen for journaling (by PSTs journaling as learners) was a combination of writing and drawing. Extracts from these journals (Figures 2, 3 and 4) demonstrate the variety of approaches taken. Of importance here is the kind of things that the PSTs chose to include in their journals. The text-only journals tended to focus more on notes and dot points from the invited key speakers. Rather than point to extended reflection on learning, these journals are more related to making sense (McNaught, 2010) of their key learnings, organising their thoughts and reminding themselves of key points. The journals which were a combination of photographs/artefacts, drawing and writing also suggest a similar use of journals. The images/artefacts were used as triggers to connect to key ideas rather than to demonstrate depth of reflection.

It is important to remember that the PSTs may be engaging in deep reflection when it comes to deciding what to include and how to represent this information in a meaningful way for themselves and this could point to an 'intermediary' step between recording information and evaluative/critical reflection. Much of the literature on both journaling and PST reflection highlights the importance of deep/critical reflection yet, the leap between descriptive reflection and critical reflection is a large one. One attempt to bridge this gap is Hatton and Smith's (1995) work in the nineties. They provide four 'levels of reflection; descriptive writing, descriptive reflection, dialogic reflection, and critical reflection. Between descriptive and critical reflection, Hatton and Smith (1995) include dialogic reflection which includes aspects such as discourse with self, seeking/proving alternative reasons/solutions. This stage of reflection is analytical and provides evidence of one trying to rationalize and/or critique. However, one can easily argue that the leap between analytical and descriptive reflection is still a large one, with many PSTs struggling to find the time and gain sufficient experience and feedback to progress from descriptive to analytical reflection. The case studies presented here point to the potential of images/artefacts to promote and scaffold this progression from descriptive to analytical reflection to create a stimulus for more in-depth reflection, thus creating an 'intermediary' step. Such a view is similar to that proposed by Cengiz et al.

(2014) who suggest that reflections could be deepened with more prescriptive or guided approaches to journaling (such as feedback-supported journaling), depending on the intended outcomes of the journaling process.

Conclusion

This article has attempted to highlight a number of ways that journals can be effectively used to support learning in mathematics and science. Drawing on the experiences of PSTs as learners and as teachers, we have sought to provide insights into how journaling can add value to the complex lives of students and teachers. We have been mindful of the workload of these PSTs while at the same time reminding them of the opportunity they now have to explore pedagogy without the everyday pressure of classroom teaching. We also see this as an opportunity to model our research practices, highlighting that despite experience we keep developing our practice and seeking innovative ways to do so. Thus, we are modelling to the PSTs that teaching is a lifelong learning journey that is always evolving. We have found that “when we interact with others in practices, to a greater or lesser extent, they change us and we change them through the encounter” (Kemmis & Edwards-Groves, 2018, p. 127).

While there were many different approaches and levels of engagement evident in the PST responses to journaling, it is clear the majority who had engaged at some level with journaling felt they have gained or benefited from the process. Even those who did not engage acknowledged they could see a number of benefits to journaling, both for themselves as reflective graduate teachers and as a tool to use in their own teaching practices. In regard to the PSTs using journaling in their own teaching, the case studies presented remind us of the flexibility of journaling, as it can be used in different ways for different outcomes. Each of the four case studies presented outlines a different approach to using journaling with students. Of particular note here was how journaling was used to support the NIT science teacher with the challenges of keeping track of so many different students across a week. The key findings from the four case studies are:

- A range of strategies were trialled, including one large journal for the whole class and inviting a small group of students to complete them rather than a whole class engaging individually with journaling.
- Journaling was used as an extension task for students who had finished their set work. They used their journals to document their learning in mathematics, responding to the affective and conceptual prompts provided.
- Each PST had different ideas on ways to implement journaling when they had their own class the following year, including sharing more of their own journaling.
- The PST reflections indicated that it was not easy implementing journaling when on placement but was worthwhile as it provided additional insights into their students’ thinking, feeling and ways of working (another connection to Kemmis and Edwards-Groves’, (2018) practice architectures of sayings, doings and relatings).

In addition, the findings point the role of an ‘open’ approach to journaling as one which can trigger the starting point for initial reflective practice. However, the transfer to more in-depth critical reflection requires more scaffolding and the use of targeted images or artefacts is one way in which PSTs can be supported to make this step into critical reflective practice. We first introduced journaling to final year PSTs four years ago and still encourage PSTs to journal. We believe that it continues to be an important tool in supporting the PSTs for whom journaling works to find their way as early graduate teachers. This is unfunded but important work that has the potential to be influential in beginning teachers’ classrooms.

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