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Numeracy Opportunities Across the Curriculum: Encouraging pre-service teachers to reflect on their experiences

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The purpose of this paper is two-fold: firstly it presents a description of the design and teaching aspects of an innovative curriculum module undertaken with pre-service teachers at the University of Tasmania. Through the module, Numeracy Opportunities Across the Curriculum, pre-service teachers were required to design, trial and evaluate maths trails with a group of school-aged students. Secondly, the processes engaged in by the pre-service teachers, along with documentation of their ability to be reflective practitioners, are also discussed. Through describing the learning experiences that were undertaken and through qualitative feedback received from the pre-service teachers, this paper seeks to provide useful information to other course designers and teacher educators.

Background

As the world is continuing to change rapidly, views about what it means to be numerate are also changing. Being numerate involves having those concepts of mathematics that are required to meet the demands of everyday life (Department of Education, Tasmania, 2002) and being numerate in today's world also requires the capacity to make sense of and be critical about presented numerical information. Recent curricula reform, such as that undertaken in Tasmania through the Essential Learnings (Department of Education, Tasmania, 2002) has been influenced by integrated curriculum, also referred to in the literature as "interdisciplinary teaching, thematic teaching, synergistic teaching" (Lake, 1994). While difficult to define, integrated curriculum transcends subject-area and disciplinary identifications (Beane, 1995) and encourages students to see the interconnectedness and interrelationships among disciplines (Lake, 1994). Although the groundwork for numeracy is laid in mathematics classrooms, other learning areas make their own demands on students' numeracy (Department of Education and the Arts, 1995) and therefore all teachers share responsibility for their students' developing numeracy.

The module, Numeracy Opportunities Across the Curriculum, was designed to develop an understanding of how numeracy could be incorporated into cross-curriculum, transdisciplinary teaching. It was offered to pre-service teachers who were undertaking their Bachelor of Education degree and were in the fourth and final year of their course. Its specific learning outcomes included:

- Development of an understanding of the numeracy demands inherent in a particular task or unit
- How to dis-embed and re-embed mathematics as appropriate

- The importance of creating a rich mathematical learning environment to promote the development of children's problem solving and thinking skills

Since the implementation of the Essential Learnings into Tasmanian schools, teachers and pre-service teachers have been encouraged to construct integrated units of work, or inquiry units, which often form the basis of their classroom planning and practices. It was a concern of the authors that when designing these units, many planners either failed to see the numeracy opportunities that were inherent in the designed tasks or failed to consider the numeracy demands that the proposed tasks were making on the intended learners. The authors sought to redress this balance by offering a module which provided pre-service teachers with the opportunity to incorporate numeracy across the curriculum through making authentic links both within and outside of the classroom.

Design of the Module

The module consisted of 12 lessons (one per week) each of two hours duration (with some class time being negotiable). The first six weeks were based around the design, modification and trial of an outdoor experience with a mathematical focus, while the second six weeks focused on design and technology. The description and evaluation of the first six weeks of the module are the subject of this paper.

The authors chose to use maths trails as a vehicle for the outdoor experience as they provided a motivating way to access numeracy outside of the classroom, and allowed students to apply their mathematical skills and knowledge in a different context. A maths trail is a walk to discover mathematics. The math trail map or guide points to places where walkers formulate, discuss and solve interesting maths problems (Schneider, Pollak & Shoaf, 2005). According to Toliver (2005), an advocate for maths trails in the United States, "As math teachers, we have the responsibility not just to develop students' mathematical skills but to prepare them to be able to use those skills in life. The math trail presents an exciting way to do just that" (para. 1).

In the first two weeks of the module students examined the features of integrated curriculum, and identified the numeracy demands within sample units of work. Time was then spent on looking at the features of a maths trail, evaluating some examples of maths trails and participating in a maths trail around the University's campus, designed by the first author. Students completed the maths trail in groups ranging from two to five, and they maintained these groups to collaboratively design their own maths trails. The location for their trail design was the Launceston Cataract Gorge, a natural reserve, featuring walking and hiking tracks, lookouts, swimming pool, suspension bridge and the longest chairlift span in the world. It is a popular excursion destination for school groups. The pre-service teachers were expected to visit the Gorge and collaboratively design their trail in the third week, and then share their trail with the class in the fourth week. Peer evaluation also occurred at this time, with the groups taking away their trails to modify as a result of this evaluation. In the fifth week, arrangements were made with a local class of school children to visit the Gorge and trial the maths trails with the pre-service teachers. In week six, the pre-service teachers met back in class to discuss their experiences and reflect on the trial.

The Study

The module was a new unit introduced for the first time with this group of pre-service teachers and the authors were interested in evaluating the impact it had on them and their perceptions of the educational value and relevance of the course. The authors were also interested in documenting the reflective processes that were incorporated in the unit and to determine the pre-service teachers' ability to be 'reflective practitioners' (Schoen, 1987). Specifically the research questions were:

- What impact did the unit have on furthering pre-service teachers' understanding of interdisciplinary curriculum and maths trail design?
- What aspects of the course (if any) did the pre-service teachers find particularly relevant and valuable?
- What aspects of learning do pre-service teachers focus on when engaging in reflection and to what extent are they able to articulate or document this?

The participants

Approximately 30 pre-service teachers participated in the study. All pre-service teachers were in their fourth year of study in the Bachelor of Education course and were enrolled in the module, Numeracy Opportunities Across the Curriculum. Following ethics approval, students were informed of the study and their consent was obtained. It was emphasised that their participation (or non-participation) was not related to their assessment for the module.

Data gathering instruments

Data were collected through field notes taken in class by the researchers, a questionnaire administered at the end of the first six weeks, follow-up interviews with five volunteers and document analysis of the maths trails produced and written reflections. The questionnaire contained 12 Likert scale items and six open-ended questions. The interviews were semi-structured (Burns, 2000), audio-taped and transcribed. Some of the instruments, such as the interviews, also doubled as tools to aid in the reflection process. The second author, and some pre-service teachers, collated images throughout the course which were produced during interviews to stimulate reflective responses. The use of visual methods in research is becoming a greater focus for researchers in a number of fields (Pink, 2001; Banks, 2001; Emmison and Smith, 2000; Rose, 2001) and can provide the stimulus for unexpected information to emerge (Banks, 2001, Harper, 1998).

Maths Trail Design

As previously stated, the pre-service teachers were required to collaboratively design their maths trails; they then had to submit this in a format suitable for use with

school students. Each maths trail had to be accompanied by a rationale, a statement of the aims, objectives and/or key understandings, instructions for completing the trail and ideas for modifications and extensions. When introducing maths trails in the second week of the module, the first author presented the pre-service teachers with some principles for designing authentic, effective maths trails and emphasised the following:

- The inclusion of important mathematical content
- Utilisation of the features unique to the site (the questions should not be able to be answered just as easily in the classroom)
- Clear articulation of the aims and purposes
- Use of a variety of question types, including those supporting higher-order thinking

These principles were used to guide the observations and document analysis of the maths trails produced in order to determine their mathematical value. Trails produced by four pre-service teachers, representing two groups, have been selected for further discussion because they demonstrate the pre-service teachers' ability to link the activity with important mathematical knowledge and utilize the features of the site. Excerpts from both maths trails are shown in Figures 1 and 2.

Chairlift Stop

Look up at the chairlift.
What shapes is it made up of?

Pretend you are a bird flying in the sky. Draw how you would see the chairlift from above.

Figure 1

SIGN 3 – Find this sign (hint: almost undercover)



What are the missing numbers from the photo?
Can I take my bag from a locker at 5:30? How do you know?

Figure 2

Amanda and Robin's Trail

Figure 1 shows an excerpt from the trail designed by Amanda and Robin. According to their rationale, their maths trail:

was designed to develop geometric thinking and an understanding of geometric concepts in grade 2,3 and 4 students. We wanted our maths trail to promote students' thinking

about different types of shapes, the properties that make up these shapes and what makes these shapes alike and different.¹

They further justified their inclusion of questions by referring to van Hiele's theory (Bobis, Mulligan, Lowrie & Taplin, 1999) of ways of understanding spatial ideas and aimed the experiences appropriately at level 0. Their justification for including the question related to the chairlift was to:

place an emphasis on shapes that students can observe, build, take apart and perceive in many different ways (Van de Walle, 2004). At the chairlift stop students are asked to focus on the shapes that make up the chairlift and to draw the chairlift from a different perspective.

Amanda and Robin also sought to encourage higher-order thinking as evidenced through their statement:

After students drew the chairlift from the bird's eye view we verbally asked them what strategies they used to do this. This question encourages students to begin to think about why they are solving a problem in a particular way...Did they visualize the image of the chairlift in their mind and then draw it? Did they think about what shapes make up the chairlift and then put them together? Did their strategies work?

Their maths trail included a range of question types and again their rationale shows deliberate consideration of this:

In the maths trail students were provided with many open-ended questions and tasks to help them build their own understanding of shapes such as the question at the BBQ stop where students were asked to describe one shape in detail. We designed the maths trail so students would be able to construct their own knowledge about shapes, their properties and where they are in the environment. Not only do open-ended questions allow students to express what they already know about shapes but they allow students to explore, discover, compare and observe shapes so they can build on this knowledge (Van de Walle, 2004).

Amanda and Robin's trail showed that they understood the purpose of a maths trail and incorporated the pedagogical principles behind maths trails into its design.

Brian and Rowena's Trail

Brian and Rowena also designed a particularly effective maths trail, choosing to focus on the more numerical aspects of the environment (see Figure 2). Their rationale shows evidence of both understanding of the principles behind maths trail design and integrated curriculum:

When the maths trail was designed, we wished to focus on a particular strand of the mathematics curriculum and relate this to the chosen environment, rather than randomly selecting aspects of the environment that could be used in conjunction with strands of the curriculum. This decision was influenced by integrated curriculum theory, which advocates authentic connections rather than the application of skills.

¹ 10-font citations indicate direct quotes from participants' reflections

Their aims reflected an appropriate focus on the important mathematics, drawing from the Tasmanian mathematics document, K-8 Guidelines (Department of Education, 1993):

- Numbers have a variety of uses and purposes
- Sometimes numbers are used simply as labels ... and do not imply quantity or order
- Numbers are useful e.g., for ordering and labeling
- We can express many things numerically: e.g., the value of money, time

While the pre-service teachers were not directed to source their aims from this document, its use is emphasized throughout the mathematics component of the Bachelor of Education course generally, enabling them to be familiar with the process of documenting their aims with reference to relevant curriculum documents. The questions posed throughout Brian and Rowena's maths trail consistently required on-site knowledge in order to be answered and their imaginative use of digital photos with parts missing provided additional motivation for the students completing the trail.

General Quality of the Maths Trails Produced

While these two examples were particularly effective, there were many other examples of important questions asked and maths trails that met the parameters of the design principles. Many trails focused on estimation and measurement, for example, and included questions such as:

- Estimate the length of the pool. What strategies did you use for your estimation?
- Estimate how many pavers you think are in the BBQ area. How did you work it out?
- Stand near the entrance of the Gorge where the metal gate leads down to the pool. Identify the main shape in the metal gate. How many of this shape can be found on the metal gate? What strategy did you use to count how many shapes were in the gate?

While some of the maths trails did include closed questions, these were usually used appropriately as scaffolding devices for follow-up questions. For example, Dawn's group asked:

- How many long green benches can you see?
- How many people can fit on one bench?
- How many could fit on all the green benches?
- Why might somebody give a different answer?

In a follow-up interview, Dawn mentioned how they included an 'easy' question:

We had a question on there, how many pieces of play equipment are there – and it was like too easy – we could have put something a bit more substantial in there – more meaningful, it was a kind of just in case question.

She then went on to elaborate on the bench question:

How many green park benches are there? How many people could sit on those park benches? So we tried to integrate a physical element into it – we didn't want them to just answer questions – we wanted them to be active and then we were like measuring out – they said 6 or something – so we all sat down on a park bench and decided how many people could fit and how could these answers be different – that kind of thing – like someone could be lying down or there could be more kids or things like that – yeah working with the kids – you get to know what works, what bores them, what doesn't.

A number of the trails included questions relating to the prices at the shop and these were examples of perhaps the more questionable types of activities included, as they could have been completed at the school canteen or from looking at a menu:

- You have been given \$20 to spend at the basin shop. You must spend as much as you possibly can of the \$20 budget without going over. Also you can only purchase one of each item available at the shop. How much change, if any, did you have left? List your items and prices here.

Some tasks required students to count items, but failed to capitalize on the mathematical opportunities that required problem solving or higher order thinking skills. For example, one group asked children to count the number of lights they saw on the path until they crossed the bridge. As children of this age could reasonably be expected to have developed one-to-one correspondence, it was not clear what the mathematical justification for this task was and it was not preceded or followed up with a more challenging question.

In summary, document analysis of the maths trails produced showed evidence that the intended learning outcomes were addressed and incorporated into the design of the maths trails. Pre-service teachers consistently chose appropriate questions to ask and generally utilized the unique features of the site. While some maths trails did include examples of less appropriate questions, these were usually identified by the pre-service teachers in the reflection processes and often adapted or modified accordingly.

Pre-service Teachers' Perceptions of the Module

Table 1 shows the pre-service teachers responses to the Likert items on the questionnaire and indicates their perceptions of aspects of the unit. 27 pre-service teachers completed the questionnaire and the results are presented as percentages. The percentages have been rounded up or down to the nearest whole number, and hence not all totals equal 100%.

Understanding of transdisciplinary curriculum and maths trail design

The first research question sought to determine the module's impact on furthering the pre-service teachers' understanding of interdisciplinary curriculum and maths trail design. As shown in Table 1, 93% of respondents indicated that the unit had furthered their understanding of transdisciplinary teaching and 85% indicated that they either strongly agreed or agreed that they had a good understanding of the subject matter. In order not to rely solely on self-reported data for this aspect, other evidence of the pre-

service teachers' learning was also elicited. In interviews, for example, one respondent reflected on the potential of maths trails to form bridges to other subject areas and stated that: "It provides an excellent focus for a field trip. I would look at combining it with other learning areas". Dawn elaborated on this further:

It's definitely something I intend to do on internship. It has helped me in that way to just think about what, not just for my internship, but for in the future, what I can do outside of the classroom and also instead of doing just a unit on one thing, think about how you can extend it into the maths area or other areas, instead of disregarding it so to speak, or even linking it and going well, OK, there's an element of measurement in this and OK doing a real focus on measurement so it all ties in, so I've started thinking about that kind of thing, so it's not all segregated.

Table 1

Statement	SA	A	N	D	SD
1. This unit furthered my understanding of how numeracy is incorporated into transdisciplinary teaching	15%	78%	7%	0%	0%
2. This unit developed my understanding of identifying the numeracy demands inherent in a particular task or activity	11%	63%	26%	0%	0%
3. Maths trails were an effective way to create a rich mathematical learning environment	59%	37%	4%	0%	0%
4. Maths trails help to develop children's problem solving and thinking skills	48%	44%	7%	0%	0%
5. Maths trails can help to develop positive attitudes towards mathematics	48%	44%	7%	0%	0%
6. This unit stimulated my interest in the subject area	30%	67%	4%	0%	0%
7. I gained a good understanding of the subject matter	11%	74%	15%	0%	0%
8. The maths trails were a valuable learning experience for me	41%	59%	0%	0%	0%
9. I have appreciated the opportunity to be involved in the unit's evaluative process	26%	56%	19%	0%	0%
10. The unit provided me with opportunities to work collaboratively with my peers	44%	48%	4%	4%	0%
11. I found the reflective process involved in the maths trail valuable	22%	52%	22%	4%	0%
12. The unit's flexible approach benefited my learning	22%	56%	22%	0%	0%

Valuable Aspects of the Module

In terms of the pre-service teachers' perceptions about the value of the module overall, responses were very positive, in that the respondents either strongly agreed or agreed with all statements, with the level of agreement ranging from 74% (for item 2) to 100% (for item 8). Short answer responses also indicated that the majority of respondents (83%) considered the use of maths trails useful or very useful to their future teaching careers and 95% indicated that they would use them in the future. Reasons given for this included the opportunity to involve children in mathematics outside of the classroom, the trails were enjoyable and stimulating for both teachers and students, they helped to make numeracy more relevant and provided for problem solving and transfer of knowledge. One respondent indicated that they would definitely use maths trails in the future as "they

stimulate interest, questions, deeper thinking and understanding – they’re fun and rewarding for both teachers and students and they can lead into other areas for exploration,” while another indicated that “I hadn’t heard of a maths trail before and would now feel confident to implement one with my class.”

The open-ended responses revealed that the pre-service teachers found the trial of the trail with the school students the most valuable aspect, along with the “hands-on” aspect, experiencing mathematics in the environment and actually designing the trail with their peers. As shown in Table 1, items 3, 4, 5 and 10 received high agreement ratings, which indicated that the pre-service teachers’ perceived the trails to be a rewarding experience for both the students and themselves.

Reflective Processes

As previously stated, the third research question sought to determine the process the pre-service teachers went through in terms of reflecting upon their experiences and how they articulated or documented this. Reflective practice has been the subject of attention for teacher educators for some time (Power, Clarke, & Hine, 2002) with the aim being to develop life-long critically reflective practitioners (Martinez & Mackay, 2002). Reflection in this context can be defined as “looking back and making sense of practice, learning from this and using this learning to affect your future action” (Ghaye & Ghaye, 1998, p. 2). The reflection processes incorporated into the module can be summarized as follows:

Reflection on the initial design of the maths trail

In week four, the class session was devoted to the informal sharing of each group’s maths trails. Peer evaluation was also incorporated into this session. Groups then had the opportunity to modify their trails based on the feedback received. Evidence of the effectiveness of this process was collected through field notes taken by the researchers during the sharing of the maths trails and through follow-up interviews with volunteers.

Reflection following the trial of the trails with the school children

In week six, the class session was devoted to the informal sharing of the experiences undertaken with the school children. Participants were invited to share their reflections as a prelude to the more formal reflections that were to be written individually. Field notes were also taken by the researchers during this session, with more detailed data sought from interviews.

Individual written reflections

As part of the assignment requirements, all group maths trails were to be accompanied by individual written reflections which could have included documented revelations about the students’ understanding of mathematical concepts, whether or not it achieved its objectives and anecdotal notes made during the trail. These written reflections were analysed by the first author.

Questionnaire completed at the end of the six weeks

Although initially developed as a data instrument to provide feedback for the designers of the module, the questionnaire served a dual purpose in that it also provided an opportunity for the pre-service teachers to reflect on their experiences. The open-

ended responses allowed for specific reflection on some aspects that the pre-service teachers may not have mentioned or considered in their individual written reflections.

Follow-up interviews

As previously stated, some pre-service teachers volunteered for a follow-up interview. This gave them the opportunity to reflect verbally about their experiences, with focus questions being used to direct the reflective process.

Visual images

In recognition of the need to provide a stimulus or prompt to aid the reflection process, the pre-service teachers who agreed to be interviewed were shown a series of photographs taken on the day of the trial of the trails and at various times throughout the course.

Reflective Themes

The data from these reflection processes were collated and analysed, and a number of themes emerged. Reflections focused around general aspects of trail design, student learning, student affective factors and self-reflection. These themes will now be discussed in turn.

General Reflections

One of the themes that emerged from the initial sharing session was that some groups found it difficult to concentrate on one particular concept. Many had intended to choose one concept and to develop this fully, but then “found it too difficult and went for variety instead”. One group felt that one concept would be “too repetitive” and Dawn also referred to this aspect in her interview stating that: “if you were trying to cover just one concept, it was difficult to keep it on that concept and not make it too monotonous...well that’s what we found anyway”. Several groups also commented on the challenge of writing questions that would cater for different age groups and knowing exactly at what level to aim the questions at. One student commented that “You could see maths everywhere, but to get students to recognize it was the challenge”. Several respondents mentioned the importance of questioning, mainly referring to the use of open-ended questions and having clear goals for students’ learning. Others mentioned more practical considerations, such as the time frame needed to complete the trail, safety and weather conditions. This was again mentioned in the final sharing session and featured strongly in the written reflections. It was also widely agreed that the experience would have been more beneficial if the ratio of students to pre-service teachers was increased (some groups had five pre-service teachers and two students).

During the peer evaluation of each other’s trails, the pre-service teachers provided generally positive feedback, with comments such as “It’s well set out”, “I liked how you used the signs” and “The sheet is clear with different scenarios”. Refinements were made based on peers’ observations, with one group realizing they had far too many questions, while another group made extra space provision for recording of children’s responses. Practical

aspects were also considered. One group, for example, had a question related to estimating the number of people in the pool and were asked by their peers what would happen if it was not a hot day and there was no-one in the pool. They then modified this question to include the number of people in the Gorge area. In her follow-up interview Dawn indicated the peer evaluation was valuable in that:

We talked about the benefits of theirs and they talked about ours and it helped us with the design of ours...it's good sometimes to be removed from your work and study someone else's because that's when you think about those things".

While some students mentioned that it would have been valuable to have seen more examples of maths trails before designing their own, others, such as Monica, thought that more examples may have "limited creativity" and thought "we had enough to go on – the doing of the trail at Uni was helpful because that made it clearer as to what a maths trail actually was – I didn't know what they were before that". The reading list on the unit outline also provided web addresses and sources for accessing other maths trails that the pre-service teachers could have referred to if necessary.

Reflecting on Student Learning

Many groups chose to focus on reflecting what the experience revealed about the children's learning. Many commented that they had over-estimated the mathematical knowledge of the children and assumed that they would know about certain mathematical concepts and then found that they did not. June, for example, stated that: "It really surprised me that they didn't know about time – I thought every child by that age would know at least how to tell the time". Monica also noted this in her written reflection, stating that:

Meg was given a watch with a minute hand so she could count the minutes while Lisa was going to count the chairs. It became clear that Meg did not understand the concept of time. She did not know the function of any of the hands on the watch, nor could she tell how long a minute was".

Other examples included symmetry: "Both students did not have any concept of symmetry" and circumference: "Students had not heard of circumference before".

When asked how they responded to these situations, many of the pre-service teachers identified that it was actually a positive experience for them, as it gave them the opportunity to use "teachable moments" and according to Dawn, "We adapted while we were there, like you would when you had a class anyway". One group responded to the children's unfamiliarity with symmetry by "linking it to things the students could relate to like butterfly paintings and then relating it to the capital letter of their first names".

Some of the pre-service teachers' reflections focused on whether or not the learning objectives of their trail were met. For example, Ann stated in her written reflection:

We wanted the maths trail to promote students' thinking about different types of shapes and the two students were able to effectively do this by identifying a variety of shapes e.g., squares, triangles, rectangles, ovals and half circles...[with regard to perspective]

Bill identified that if he was bird flying above he would have seen the roof of the chairlift and the legs of the person sitting in the chairlift.

Several pre-service teachers commented on the strategies students used to solve problems. Dawn, for example, in her interview described how students determined how many pavers were in the bbq area:

At first they were just quick off the bat – but we wanted them to really think about it...we said, how could you figure it out...then one of them got up and started counting how many tiles were on one side and then on the other one and at the same time, the other one went to the other corner and was using his feet to do it, so in a way they figured it out themselves...

Others acknowledged that the learning that occurred would need to be linked to the classroom program. Short answer responses to the survey questions illustrate this:

Because we could not target maths to specific children and because we were all focusing on different things, I think following up the learning in the classroom would be challenging.

It would depend on what the class teacher did back in the classroom. It would be of great benefit if the trails complemented the class program.

Students' Affective Factors

Most of the reflections made by the pre-service teachers included comments about the affective traits exhibited by the students. There were many comments relating to the children enjoying the activities and most trails factored in a section where children could comment on how they felt about completing the trail. Aspects of students' behaviour were also noted. One group had a student with autism, and noted that when they were at the bridge:

...he had began to lose concentration and attention. The loud noise of the water was very annoying for him and he placed his hands over his ears and the teacher's aide told us this was one of the signs of autism, that they don't like loud noises

The group wisely decided to move to a different location and reflected that next time, they could modify their trail to avoid this variable. In another situation, a pre-service teacher was observed responding quickly to a support a student who had lost count (for the second time) whilst counting steps around a pool. The pre-service teacher anticipated the student's distress and completed the activity alongside them. Other pre-service teachers' reflections also showed that they were sensitive to signs of frustration or disinterest and adapted their trail or questions to accommodate this. One pre-service teacher, Brian, documented that one of his students said "he was not good at mathematics" and that this resulted in a reluctance to participate, while others expressed surprise at how confident the children seemed and how willing they were to cooperate and communicate with them.

Personal reflections

There were a few reflections that related specifically to how the pre-service teachers themselves felt about their role. One student, Sarah, included in her written reflection, “At first I stood back and let the others do all the talking because I was unsure of how much to tell them, but I became more confident with that as we got further into the trail”. Another student, Suzie, commented that, “It raised a lot of questions, like how much should I tell them? Should I intervene if it seems too hard? Should I correct them if they give the wrong answer?”

Impressions of the Reflective Process

While Table 1 shows that 77% of respondents found the reflective process valuable, 22% responded neutrally to this and 4% disagreed. Follow-up interviews revealed that the pre-service teachers were not entirely sure what they needed to reflect on and would have benefited from more guidance in this area. One pre-service teacher suggested that a checklist which outlined suggestions of what to reflect on or about would be helpful. She mentioned that her group had made a lot of anecdotal notes while undertaking the maths trail with the children but had not thought to include these with her written reflections.

With relation to the use of still images to stimulate reflective responses during the interviews, some unexpected interpretations occurred. For example, one pre-service teacher, whilst viewing a photograph taken by an entirely different group, commented:

It's great to see the uni student's look of engagement....you can actually see them explaining to the kids what they need to do and you can see the kids...they're really enthused about what they're doing.

Subsequent conversation related these secondary visual reminders back to their own group responses. Pre-service teacher reflective comments in relation to the use of digital cameras (still and video) ranged from comments supporting their use as a *reflective* tool (a reminder of processes, specific events and occurrences throughout the day) to comments relating to their value as a *teaching* tool (where students could have reminders of their learning process, could see the learning of others in action, or could use photographs as part of a visual storyboard presentation of their completed trail). Monica's comment supported the gathering of visual data as a valid alternative to standard assessment forms: “ We don't live our lives on a piece of paper”.

Conclusions and Implications

Through examining the data collected throughout the delivery and conclusion of the six weeks, the authors are reasonably confident that the module was of value to the pre-service teachers and did increase their understanding of how to incorporate numeracy across the curriculum. While the study is limited in that it involved only a small sample of pre-service teachers and no data were collected regarding their relevant understandings prior to commencing the module, the pre-service teachers responses to the items in the survey reflected high levels of satisfaction. The reflective process that the pre-service teachers engaged in revealed that they could evaluate their maths trails in terms of their mathematical significance and potential to develop students' understanding. The process

also served to bridge the gap between theory and practice (Taylor, 2002). There is a perception among many pre-service teachers that this gap does exist and some research (e.g., Cripps Clark & Walsh, 2002) has shown that few pre-service teachers were able to see the connections between units taught and their future career until they were in the last semester of their study.

Most respondents indicated that they would incorporate maths trails in their future teaching and the maths trails produced by them are to be compiled into a resource book for other teachers to adapt according to the needs of their particular students. For the course designers, valuable feedback has been received to further enhance the module for next year. Future considerations include increasing the number of school children involved in the trial of the trails, using the trails produced by this year's group as examples for next year's cohort and designing the trails in a different location to avoid duplication. The researchers have also been informed about different reflective processes and their relative effectiveness, including the need to scaffold the reflection process. The potential of using still images as a stimulus for reflection was also noted, and digital photographic tools for producing a visual record of processes would be actively (and equitably) employed in future course design. It is hoped that this paper has provided teacher educators with valuable information about course design and evaluation, along with some of the processes that can be utilized when encouraging reflection.

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