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Professional Learning Intervention in Mathematics: A Case of Developing Portfolio Assessment

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Abstract: This paper reports findings from a Fijian study that engaged secondary mathematics teachers in a two-day professional development workshop on the use of portfolios as an alternative means of assessing student learning in mathematics. Utilising an action research approach with a view to involve teachers as key stakeholders in mathematics education, the professional development prompted a small group of secondary mathematics teachers to think about the mathematics content and processes which could not be assessed using written tests, and to develop assessments that would reflect higher-order thinking in mathematics. While the majority of the teachers came up with ideas that were well suited for portfolio assessment, some participants faced minor difficulties in relating to real-world experiences and developing higher-order tasks. Teachers were able to come up with teaching and learning activities that could be used for portfolio assessment. At the end of the workshop ten of the 12 teachers were interviewed to gain an insight into their experiences. All of them stated explicitly that they had found the workshop very useful and rewarding because portfolios could provide an alternative way to assess student learning, and could possibly influence the way they taught mathematics.

Introduction

Although the field of assessment, and especially formative assessment, has received a lot of attention in the last decade, there are still questions about: what the term means to teachers (Dunn & Mulvenon, 2009), how teachers view the purposes of assessing student learning (Brown, 2003), and how to design and implement effective formative assessment practices at the classroom level (Black & Wiliam, 1998: Black, Harrison, Lee, Marshall & Wiliam, 2003; Cowie, 2005; Cowie & Bell 1999). Seminal works such as that of Black and Wiliam (1998) provide evidence that formative assessments, when well implemented, result in improved learning and motivation. Such findings have led to increased attention being given to formative assessment, or assessment for learning. Assessment for learning can be differentiated from other types of assessment by its purpose, where the "priority is on enhancing rather than measuring learning." (Cowie, 2005, p.137). Assessment becomes formative when, according to Sadler (1989) judgments about the quality of pupil responses are used to improve pupil learning.

According to Sadler, this means closing the gap between a pupil's actual level of competence and some desired level of competence. Seen this way, formative assessment consists of "all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged" (Black & Wiliam, 1998, p.7). In other words, provision of effective feedback that has the potential of improving learning is the main idea behind the use of formative assessments.

Portfolio assessment is one possible formative assessment strategy although it has received little attention in the formative assessment literature (Klenowski, 2002; Tierney & Charland, 2007). According to Gronlund and Waugh (2009), a portfolio is a collection of student work that captures progress in learning with respect to a particular learning domain. In addition, portfolio assessment has the potential of involving students in the formative assessment process through engagement in peer and self – assessment. This means that portfolio assessment can provide the platform for the students to 'talk about' their strengths and weaknesses with their peers as well as to reflect on their own learning. Tierney and Charland (2007) point out that very little research has focused on 'student voices' in assessment, something that is inherent in portfolios. Portfolio use can help students improve their self-assessment skills and thus lead to improvements in other related areas such as communication and problem solving (Klenowski, 2002). However, the use of portfolios to enhance learning and teaching practice becomes challenging in an education setting that values traditional methods of assessments such as examinations. A system that values quick results in terms of quantifiable outcomes is likely to oppose an expansionist assessment system such as portfolios that values both process and product (Klenowski, 2002).

Similar challenges have generally been encountered in assessments worldwide. In other words, teachers have traditionally had difficulty in implementing assessment for formative purposes. For example, Black and Wiliam (1998) and Black, Harrison, Lee, Marshal, & Wiliam, (2003) conclude that teacher practises related to classroom assessment are weak. Black and colleagues (2003, p.11) categorized the main problems of everyday practice of assessment in classrooms in the UK and elsewhere that included problems such as a lack of focus effective learning; assessments having a negative impact on student learning and motivation; and, the issue of the managerial role of assessments. A majority of these challenges are somewhat related to teachers, because it is the teachers who design and use assessments at the classroom level.

The current study noted the constraints on the development of effective formative assessment practices (Black et al., 2003), including portfolios. However, we were guided by Klenowski's (2002) suggestion that despite being in its infancy, portfolio assessment has the power and potential to transform teaching and learning. Realizing the importance of teachers' roles in effective classroom instruction and assessment, in conjunction with the need to provide professional learning opportunities for the practicing teachers, we worked with 12 secondary mathematics teachers over a two - day professional learning workshop that focused on formative assessment in mathematics in general, with particular emphasis on developing portfolio assessment to be used in Year 9 classrooms in Fiji (Hattie, 2003; Haertal, 2013; Kieran, Krainer & Shaughnessy, 2013; Shimizu, 2013). While the main aim of the larger study was to explore teachers' use of portfolios as a form of assessment in mathematics classrooms, we report on the following specific research questions in this paper:

1. When provided with support, to what extent do mathematics teachers accept the idea of portfolios as a means of assessment?
2. To what extent do teachers find workshops support useful for their classroom practise?

The next section discusses portfolios purposes and processes. The theoretical orientation of the study is then presented. This is followed by a literature review where we look at two large professional development programmes involving teachers. Next, the methods used in this study are described and results are then presented and discussed. The paper ends by noting a few implications of our findings.

Portfolios: Purposes and Processes

> *Arter and Spandel (1992, p. 36) define a student portfolio as:*
> *A purposeful collection of student work that tells the story of the student's efforts, progress, or achievement in (a) given area(s). This collection must include student participation in selection of portfolio content; the guidelines for selection; the criteria for judging merit; and evidence of student self-reflection."*

This definition moves us away from the naïve and unnecessary proposition that it is possible to attempt to explain a child's learning by assessing it through only one lens. Seen this way portfolios provide an opportunity to use multiple tools not only to measure learning but also to appreciate the complex dimensions of a child's learning (Shepard, 2000; Klenowski, 2002). Portfolios can be used for a range of purposes, including learning, assessment, appraisal, and promotional purposes. A portfolio can be used for a range of assessment purposes that may include formative purposes that support teaching and learning processes (Klenowski, 2002). For Klenowski (2002), the use of portfolio offers the opportunity to integrate assessment with curriculum. In addition to this, the use of portfolios supports the idea of meta-cognition. According to Klenowski (2002), "meta-cognitive growth that is intended in the development of a portfolio of work suggests that it is a means by which students may demonstrate their learning but more importantly involves processes and a mode of learning that encourage them to take responsibility for their own continuing learning" (p.4). In other words, it is not the product in isolation but both process and product that are important.

Portfolios can be used to support learning and teaching. This is because assessment that enables students to develop and improve their learning rather than limiting them can be seen as formative assessment. For students to learn, their development of their motivation and confidence is very important. Portfolio use can help students improve their self-assessment skills and thus lead to improvements in other related areas such as communication and problem solving. For portfolios that aim to improve or support student learning, it is best that the main responsibility for managing the portfolio rests with the student (Klenowski, 2002).

Klenowski (2002) discusses three important processes in portfolio assessment. These are self-evaluation, substantive conversation, and reflective thinking and practice. *Self-evaluation* requires learners to select important items from their own work. This selection must demonstrate that learning has taken place as expected. This process helps "students to think critically about their learning, to understand the standards of performance that drive their work and to critique their own work in relation to these standards" (Klenowski, 2002, p.28). *Substantive conversation* involves conversations which take between peers, mentors and the teacher. A form of "focused intervention" (p.32), this dialogue links to the idea of working in the zone of proximal development (ZPD). This interaction helps in meta-cognitive development. In other words, such interactions help students to think about their own thinking and learning. *Reflective thinking and practice* involves students identify their own strengths and weaknesses. Reflection begins when a

state of doubt is created or realized, and then the learner makes every effort to resolve the doubt. Reflection is not an activity that happens in a single incident, but something which occurs over time. These three important learning processes are developed and enhanced as learners work towards developing their own portfolio. The theoretical stance of this study is presented next.

Theoretical Orientation

According to Wiliam (2007), the main actions involved in assessment for learning are: clarifying and sharing learning intentions and success criteria with learners; engineering effective classroom discussions, activities and tasks that elicit evidence of student achievement; providing feedback that moves learner on; activating students as owners of their own learning; and, activating students as instructional resources for one another. The strategies Wiliam offers are in line with the socio ─ cultural learning theory, which places greater emphasis on active student engagement in learning. In a socio-cultural understanding, cognition is seen as "extending out into the world and as being inherently social" (Cobb, 2007, p. 23). The nature of portfolio assessment fits well with formative assessment strategies proposed by Wiliam (2007). These ideas, when combined with the learning processes implicit in portfolio assessment identified by Klenowski (2002), resemble closely the socio- cultural views on learning and assessment. For example, portfolios allow for active involvement of students in terms of selecting the entries for the portfolio and maintaining the portfolio. The inclusion of student self-reflections on entries they have chosen shows how a student learner is developing.

Another important feature of the sociocultural theoretical perspective is the notion of a community of practice. Lave and Wenger (1991) argue that learning takes place when individuals move from reasonably peripheral participation towards a more progressive participation in the practices of communities. This indicates that the notion of a community of practice would have a lot to offer in terms of explaining how an individual (for example, a mathematics teacher) functions within the structural or organisational features of a school and how he or she responds to and accesses opportunities for professional development in shaping his or her instructional practices. Cobb (2007) notes that despite the possibilities of the sociocultural perspectives of learning, mathematics education researchers have not made full use of it. Researchers in the area of educational assessment in general and formative assessment in particular have shown an increasing interest in this theoretical approach. For example, Heritage (2014) argues that the idea of the ZPD requires teachers to work "on the edge of learning" (Heritage, 2014, p. 12). In other words, teachers must generate and interpret data about the child's ZPD - the level of potential development which the learner is able to move to under the guidance a more knowledgeable person (Heritage, 2014). This can successfully be done if teachers know what competencies the child currently has and how these can be developed through interactions with knowledgeable others towards a more advanced state of prowess.

The idea of community of practice was important for our study because we proposed a newer form of assessment for mathematics teachers in Fiji – portfolio assessment. Building on Handel and Herrington (2003) and Guskey (2002), our study was informed by the view that professional development would likely be successful if teachers' beliefs about change are considered and confronted, and teachers are seen as key stakeholders in the research process (Kieren et al., 2013). Furthermore, we considered that research involving teachers needed to provide them opportunities related to their classroom work (Kieran, Krainer & Shaughnessy,

2013; Shimizu, 2013). We recognised that teachers will maintain their own agendas in the privacy of their classrooms and the implementation process will be superficial and thus a "waste of energy and resources" (Handel & Herrington, 2003, p.65) if there was a lack of genuine participation and ownership from the teachers. Guskey (2002) argues that improvements in students' learning are one of the motivating factors in teacher change. In other words, teachers will support professional development programs and want to participate in them if they see that a program is likely to increase their knowledge and skills in a way that leads to an increased level of performance in their students as well. Our research was guided by this intention as we engaged 12 secondary mathematics teachers to form communities of practice that would allow them to discuss freely about assessment matters related to Year 9 mathematics.

The Nature of Effective Professional Development

Here we review two large scale professional development interventions: one from the US, and the other from the UK. These were selected because they provided a clear understanding on how teachers could be involved in questioning their current practices on assessment and then challenged to redesign their own assessment practices in order to support student learning.

Webb (2011) discusses a model of professional development in the United States which takes us close to the central problem of the current research study as it deals with how grade 8 mathematics teachers engaged in professional development aimed at designing and using formative assessment to support and improve student learning. It took Webb two projects spanning eight years, to design and fine tune his model of professional development to improve teachers' assessment practices.

Webb's first project, called the *Classroom Assessment as a Basis for Teacher Change* (CATCH), aimed at helping teachers change their instructional practice by first changing their formative assessment practice. The first part of the project saw teachers moving away from the simple *reproduction* level of thinking (parallel to the *remember* level in the revised Bloom's taxonomy; parallel to what NRC (2001) call *procedural fluency*) to two (higher) levels of thinking, based on the *Dutch Assessment Pyramid*. These were Level II – connections and Level III – analysis (Webb, 2011). Levels II and III could be paralleled with the mathematical proficiency strands of *conceptual understanding*, *strategic competence*, and *adaptive reasoning* (NRC, 2001). The professional development engaged teachers in developing assessment tasks that would be relevant for assessing all the various levels of mathematical thinking. Apart from becoming well versed in different levels of mathematical proficiency, and being able to develop tasks at various levels, the biggest challenge for his professional development design was to help teachers understand how they could use higher-order thinking tasks in their classrooms.

Webb (2011) found that although teachers are able to develop higher level tasks and are aware of their weaknesses in using of limited assessment strategies, they feel that higher-level assessment tasks may be too difficult for their students. In order to challenge teachers to take up higher level tasks in their classrooms, the professional developers asked teachers to select only one aspect of classroom assessment that they would want to try out in their classrooms. This resulted in teachers taking up higher level assessment tasks of their own choice in their classrooms. Overall, after two years of continuous support, CATCH teachers were able to give greater attention to and had a greater appreciation of the role and use of higher level tasks in mathematics classrooms.

Another notable intervention study in educational assessment was conducted by Black and his colleagues who carried out an intervention program with English, mathematics and science teachers in England (Black et al., 2003). Based on the earlier work of Black & Wiliam (1998) in *Inside the Black Box*, the authors set out to explore how the idea of formative assessment could be used by teachers in their daily classroom work. The overall aim of the project was to develop and implement a formative assessment professional development program in the normal professional practices of teachers and to explore the advantages of such implementation. Another related aim was to find out ways in which the project program, if successful, could be used as a basis for future in-service training of teachers.

According to Black et al. (2003), the first step was to look for schools that could partner in their project. Once the partner schools and teachers were identified, "teachers were to plan and implement individual innovations in their classrooms, and then to evaluate these, particularly by reflecting on their experiences in developing formative assessment" (p.18). The in-service training (INSET) saw teachers and researchers come together to discuss important issues. The researchers also visited each school site to meet individual teachers. The INSET program requested teachers to develop their own *action plans* (Black et al., 2003, p.21) based on the research findings identified in *Inside the Black Box*. Teachers were given full freedom to explore the topics of their choice with a class of their choice. Although the authors acknowledge that development and implementation of formative assessment will probably be a risky journey, they assert it is a journey worth taking, not only because of the benefits directly associated with student learning, but also for the implicit benefits in terms of what we can learn for our future work in the area of professional development of teachers. In summary, the overall aim of the INSET program was to develop and implement formative assessment in the normal professional practice of teachers and to explore the advantages of such implementation. The researchers asked teachers to plan and then implement individual innovations in their classrooms, and later to help evaluate these by reflecting on their experiences in developing formative assessment.

The intervention program carried out by Black et al. (2003) involved more teachers and subject areas than either of the Webb studies or the current study. The program took a more open-ended approach as is appropriate when we talk about formative assessment. Restricting teachers' freedom to choose does not fit well with the spirit for formative assessment. Our study was a rather restricted one given that it allowed teachers to develop ideas related to student portfolios only. However, what we found useful from these two studies was the notion of providing opportunities and support to teachers in developing ways of assessing higher-order thinking in mathematics. The reason for selecting a broader form of assessment such as portfolios was mainly because assessments in general education as well as in mathematics education in Fiji are predominantly in the form of written tests that usually measure recall of mathematical facts and procedures (Dayal, 2013; Dayal, Lingam, Sharma, Fitoo & Sarai, 2018). Against this backdrop, we conjectured that portfolios would provide the necessary platform for teachers to discuss and develop better assessments. The study's methods are discussed next.

Methods

The intervention design our study for was guided by a belief in the need to engage mathematics teachers as key stakeholders in mathematics education research (Kieran et al., 2013; Shimizu, 2013). Hence, one of the major elements of an intervention design was partnering up

with the teachers. The design is described in some detail next followed by what transpired in the two-day workshop.

Partnering up and Gaining Access

The most important partners in this study were the mathematics teachers. The researcher identified two secondary schools by liaising with Ministry of Education officials, and they were invited to participate. The school principal and the head of department from each school agreed to be part of the study. The two schools were Kaivata College and Marau College (pseudonyms used). Once consent was gained, the researchers negotiated possibilities for carrying out the intervention research through meetings with the school principals and the heads of departments. Later, the teachers of both schools were consulted and invited to participate. This was made possible when the heads of department called special department meetings and allowed us to introduce the research aim in person with the teachers. During our initial meeting with the mathematics department teachers, we discussed the overall aims of the project and the time and resource factors that would need to be considered. Two important questions, which were clearly explained, included: What are we going to do? How will we do it?

Prior to our meeting with the teachers, we had anticipated a number of short combined sessions of professional development with teachers from both schools. However, when in the field, we realized that gathering teachers from two schools together on many different occasions would be a difficult task. With the approval of the teachers, Heads of Department, and the school principals, we agreed to have two full-day workshop sessions at one of the schools at which teachers from both schools would be present. The focus of the two-day intervention was on portfolio assessment. With the term one holidays approaching, we agreed to schedule the workshop on the final Friday of term one (Friday 24th April, 2015) and Saturday (25th April, 2015). These days were appropriate given that the aim was for the actual implementation at the start of term two. Twelve teachers attended the workshop on Friday, and ten teachers attended on the Saturday. Two teachers could not make it on Saturday because of personal commitments. The workshop had six sessions (three sessions per day) and teachers were set different tasks for each session. These are described next.

Intervention Activities

After an introductory session by the first author, teachers were asked to go over the major components of the Year 9 mathematics curriculum and choose one topic for portfolio assessment. Teachers divided into three groups of four teachers, preferring to form groups with teachers from their own school. The teachers chose to work on the topic ‘Measurement’, which is also known as social mathematics in Fiji. This topic was chosen for portfolio assessment because both the schools would teach this topic at the start of term two. In order to develop student portfolio assessment, teachers needed a thorough understanding of the content and the processes to be assessed. The stands of mathematical proficiency (NRC, 2001) were useful in mapping out what mathematical outcomes teachers considered important and how they planned to assess those outcomes. Since newer assessment techniques meant that teachers needed to re-think their current teaching methods, it was important for each school to work towards modifying their teaching and learning plans for the measurement topic. Once teachers had talked

in detail about the mathematical content and processes related to the topic 'Measurement', each of the three groups presented their summary of the main mathematical themes in the topic 'Measurement' to each other during session one on the first day.

The groups then worked on identifying tasks or activities that could help in learning and also elicit important information about different levels of mathematical proficiency. While teachers were working on developing these activities, they were also thinking of how these activities could be used for portfolio entries. In other words, they were working to develop good teaching and learning activities that would also be possible entries for portfolio assessment. While many teachers had already identified possible activities during session two on the first day, groups were now also tasked with deciding which activities could be used as 'final portfolio entries'. At first, the plan was to decide this collectively. However, teachers were unable to reach consensus in the larger whole group. We again went back to the smaller groups of four and each group worked with a limited number of sub-topics and learning objectives during session three of the first day. For example, group one worked on simple money calculations, group two on ratios, and group three on rates. This way of finalising a content/conceptual focus and portfolio entries was seen as useful because each group focused on limited learning objectives, thus ensuring that the group task was completed on time. By the end of this third session, all three groups had a fair idea of which entries would form part of student portfolio assessment.

At the start of the second day, the groups were tasked with finalising the portfolio entries. This also meant writing out the activities and working out the marking criteria for each activity. All the groups came up with more than one activity for each particular learning objective. This was done to encourage students to "select" one of the activities for their portfolio. During the second session of day two, teachers were able to finalise all their activities, including the marking criteria. Four main activities worth five marks each were suggested for inclusion in portfolio assessment. With the exception of the sub-topic 'rates', for which there was one short test on 'rates', the teachers had prepared more than four activities on each theme.

The final session of the workshop focused on summing up the main findings to do with portfolio entries. Each head of department selected one teacher from his or her school who would implement the portfolio assessment in term two. While these two teachers were nominated by their Head of Department, the two teachers voluntarily agreed to complete the tasks. Finally, the teachers were asked to give a short interview report on their experiences of the two-day workshop sessions.

Parts of the two-day workshop proceedings were video-taped. This included group discussions and presentations as well as one-to-one interviews with ten participants at the end of the second day. Analysis of the workshop data was based on how teachers participated in activities and what professional knowledge and skills they learned and shared. In order to provide more clarity to the process, we analysed the workshop activities under four parts: understanding portfolios, identifying mathematical content and processes, developing mathematical tasks, and, finalizing portfolio entries. For some of the findings reported under the heading 'understanding portfolios', we used data from one-to-one oral interviews with teachers. These interviews took place prior to the workshop and were audio-recorded. Video-taped one-to-one interview data was used to elaborate themes for the section on 'teachers' perceptions of the usefulness of portfolio assessment'. For this paper details such as participant information and case study school information are included in table 1. Pseudonyms are used for the schools and teachers.

School: Pseudonyms	Name: Pseudonyms	Gender	Years of teaching	Qualifications
Marau College	Ana	Female	12	Bachelor of Education Post Graduate Diploma (Mathematics)
	Bhim	Male	11	Bachelor of Science, Post Graduate Certificate in Education, Post Graduate Diploma (Mathematics)
	Cathy	Female	5	Bachelor of Commerce (Mathematics/Economics). Enrolled in Graduate Certificate in Education
	Ella	Female	4	Bachelor of Science (Mathematics/Chemistry), Graduate Certificate in Education
	Fran	Female	7	Bachelor of Science (Mathematics/Chemistry), Graduate Certificate in Education
	Gavin	Male	20	Diploma in Education (Mathematics/Science)
	Haris	Male	6	Bachelor of Science (Mathematics/Physics), Graduate Certificate in Education, Post Graduate Diploma in Renewable Energy.
	Isha	Female	8	Bachelor of Science (Mathematics/Chemistry), Graduate Certificate in Education
Kaivata College	Jenny	Female	6	Bachelor of Science (Mathematics/Chemistry), Graduate Certificate in Education. Post-Graduate Diploma in Mathematics
	Kumar	Female	3	Bachelor of Science (Computer/Information) Enrolled in Graduate Certificate in Education
	Ledua	Male	16	Bachelor of Science
	Mere	Female	5	Diploma in Education (Mathematics/Science)

Table 1: Research Participants

Findings and Discussion

The findings reported in this section are a description of the workshop, divided into four main subsections: understanding portfolios; identifying mathematical content and processes; developing mathematical tasks; and, finalizing portfolio entries. A final section presents, in brief, teachers' personal reflections on the intervention.

Understanding Portfolios

The use of portfolios as a new assessment tool was the key area of focus for the first part of the intervention. Before this term was introduced and defined, we kept in mind the interview data where majority of the teachers had indicated a moderate to good understanding of the concept of formative assessment. Also noted during the interviews was teachers' lack of understanding about portfolio assessment. Only four teachers were able to give some insight into portfolio assessment then. In general, it could be said that this group of mathematics teachers were not well versed with the idea of portfolio assessment. However none of the teachers had

ever experienced portfolio assessment, neither as a student nor as a teacher. We decided to take them through the definitions offered by Arter & Spandel (1992). Building on this knowledge, we asked the teachers to identify the key terms in the definition, which they could read on the PowerPoint, and to underline or highlight them. Then we asked them to discuss their ideas in their small groups. Teachers then shared the key terms they had underlined:

Facilitator – we will start with group
Group 1 (Cathy)– The main term in the first definition is purposeful.
Facilitator – What does it mean?
Group 1 (Cathy) – It means something which has some meaning…or some aim or objectives
Facilitator – Any other groups? What about group 2?
Group 2 (Bhim) – reads "tells a story of progress".
Facilitator – what does that phrase tell us?
Group 2 (Fran) – it indicates that portfolio assessment is spread over time, that's why it is able to give a broader picture…tells the story…means that it tells much more than the marks or grades which a student gets.
Facilitator - thanks…can we hear some other key words from the first definition from group 3?
Group 3 (Mere) – yes…we find the words student participation to be one of the key words/phrase.
Facilitator – okay…can you tell us why that phrase is relevant?
Group 3 (Mere) – student participation means that children are working in groups or doing some work on their own. Just like in our class-based assessments, they do their projects etc.

Following this exercise, teachers were able to explain to each other the important ideas implicit in portfolio assessment. At this time, the teachers were asked to think about this question: How could we develop a portfolio assessment for Year 9 students? The next section captures something of how the teachers went about developing Year 9 portfolio assessment on social mathematics.

Identifying Mathematical Content and Processes

From this activity onwards, the teachers felt comfortable working within their own school groups. Therefore, teachers from Kaivata College formed two groups (Group 1 had Gavin, Isha, Cathy and Ana; Group 2 had Bhim, Ella, Fran and Haris), while the third group was made up of the four teachers from Marau College (Jenny, Kumar, Ledua, Mere).

This workshop activity consisted of the following parts: Going over the Year 9 prescription and scheme of work on Measurement; identifying the overall aim of the unit, identifying the main content and processes which students were supposed to learn, discussing which areas of the content could easily be tested using a pencil and paper test, and which ones couldn't be easily tested, discussing some ways in which the areas identified as problematic could be assessed, and presenting group findings.

The overall aim of this session was to allow teachers to discuss in detail the major content and processes involved in Measurement at Year 9 level. As teachers worked through the activity, snapshots of discussions taking place within each group were captured on camera. The group presentations were also recorded. Teachers used charts to provide a print summary of the main

content and processes, and the related teaching and learning activities they had identified that could become portfolio entries.

The Year 9 and 10 Mathematics Syllabi is a 46 page document (MOE, 2015) and Year 9 has 5 major topics: Numbers, Algebra, Functions, Measurement, and Geometry. The topic of focus for the group activity and portfolio assessment workshop had the following major key learning outcome: "Students to develop skills and understanding to become self-motivated, confident learners through inquiry and active participation in challenging and engaging experiences" (MOE, 2015, p. 10). The key outcome specific to measurement read: "extend knowledge on the use of money, calculations in terms of percentages, ratios, proportions, and rates and its applications in daily real life situations" (MOE, 2015, p. 10). We suggested to the teachers that this overall aim could become the main purpose of the portfolio assessment.

The Year 9 & 10 Mathematics Syllabi has a special section devoted to assessment. This section makes it explicit that learning in mathematics is to be assessed using both formative and summative techniques. However, portfolio assessment is not amongst the recommended assessment methods.

There were a total of 11 learning objectives related to different aspects of measurement. Teachers pointed out that all the topics could be tested using pencil and paper tests. Conversation from group 1 revealed however that teachers felt that pencil and paper tests could not capture everything. The conversation also revealed that teachers understood the overall learning outcome as more than simple recall of facts.

Isha: (Reads out the second learning outcome) – identify and describe a ratio and equivalent ratios
Cathy: Yes, that can be assessed (meaning assessed using a test)
Isha: Assessed…yes
Cathy: How about the second one (referring to the next learning objective)…that can be assessed yeah
Cathy: Solve ratios and apply to decreasing quantities (reads out this learning objective)
Ana: The calculation part can be assessed.
Isha: It can be the calculation part but what about the exploring part?
Researcher: So you are noting some of the things which can be easily tested and differentiating between what can't?
Gavin: Yes
Ana: Solve ratios can be easily assessed.
Isha: What about exploring…I mean in real life
Cathy: Yeah…(reads out the content learning outcome…) use examples from real-life situations.
Ana: what about exploring in real life situations

The above discussion reveals that while teachers generally agreed that while simple recall of facts could be tested using a pen and paper tests, real-life applications and higher order mathematical processes such as 'exploring' could not be easily tested using written tests. The group members were thinking about real-life applications and making references to rich classroom activities as a means of assessing higher-order learning objectives. The conversation between members of group one continued as follows:

Ana: But it can be assessed in different ways…not only pen and paper…even that one…ratio.

Isha: We can give one class activity…divide students into groups
Ana: Or even we can take things…say…one whole bottle of liquid and a half bottle of liquid…they will look at the ratio.

The discussion seemed to point out that although teachers had a clear understanding of the curriculum content, the application of this content such a ratio and proportion to real life was quite challenging. For example, Ana's suggestion of having two bottles of liquid did not indicate an application of ratios and was thus unclear. As the discussion progressed, these difficulties seemed to ease as the teachers provided examples to make sense of the real-life application of the mathematics in the unit.

Teachers in this group returned to discuss a learning objective to do with simple real life calculations involving money.

Cathy: What about "perform simple calculations like profit and loss"?
Isha: We can give examples or cases of market vendors.
Gavin: Yeah…money gained or lost (referring to profit and loss).
Isha: Yes, because some parents are market vendors.

At times teachers' examples seemed simple yet realistic. At times their discussion did not reveal a clear understanding of real life applications, and they suggested activities that were not in line with the learning objectives. The following example was noted when teachers in group one were discussing calculating rates.

Cathy: Calculate rates
Isha: Calculate rates
Gavin: (Offers his definition) Rate is instantaneous…average rate over a period of time.
Isha: Average of…if we buy four items from shop one and four items from shop 2, which one is cheaper? We can have one activity like that…average is there.

This discussion confirms teacher Isha was unable to conceptualize the idea of instantaneous rates suggested by group member, Gavin. Although her example was related, it did not reveal a clear understanding of rates. Her understanding of rates as a 'better buy' situation did have an idea of 'average' price as the rate however there are other more realistic situations of rates or averages that might be more suitable for a Year 9 class. Shopping situations did not provide a meaningful context of discussing rates using the definition suggested by Gavin. Another similar example was given by teacher Haris from group two: "We can talk about average prices…It's more important that students take a practical approach …they can visit a few supermarkets and work out prices of common items and finding their average prices. They can't do this in their classroom." The question of how finding the average price of a given good would be beneficial to students was not talked about. For example, if a student knew that the average price of a special soft drink is $1.50, what would this mean to the student? Some examples suggested by teachers therefore, did not clearly match the idea of rates as an average.

However, on most occasions teachers were able to give very good real life examples of the mathematics from the unit. For example, on proportions, Ana from group one said "another good example is water and electricity bills…on proportions…the more you use…the more you pay." On performing simple money calculations, Ledua from group three shared his group's ideas:

This is one particular objective that can be tested easily using pencil and paper tests. But we suggest a real-life example which the students could use to help their parents with weekly shopping…and making shopping lists. They could

compare prices of basic food items using newspaper advertisements and suggest which supermarkets are cheaper or which items to buy from which supermarkets. They could then put this analysis in their learning portfolio.

The discussions revealed that teachers were able to conceptualize that mathematics was not all about simple recall of facts as a result of thorough group discussions. The groups pointed out the importance of taking a practical approach to mathematics, and at times this seemed a challenging task for them. In general, teachers, having worked in groups, could identify the higher-order mathematical processes in the teaching unit and were able to discuss rich teaching and learning activities for their class.

This workshop activity also indicated that teachers moved away from the 'testing' culture in their discussions, and focused more on teaching and learning scenarios and activities. It can be argued that having teachers discuss the curriculum content in detail proved to be a good way of making pathways for them to begin thinking about formative assessment. Teachers developed teaching and learning activities that had the potential to form one of the core elements of formative assessment. As noted by Black & Wiliam (1998), developing "learning tasks that elicit evidence of learning" is a formative assessment action that has been shown to help improve learning. In order for teachers to move towards formative assessments, teachers must first understand what mathematical content they are going to teach and the different mathematical processes which could be developed in their students as a result of going through that content and the context of different tasks. The mathematical tasks that groups came up with are discussed next.

Developing Mathematical Tasks

Each group presented the main teaching and learning ideas they had developed. These reflected many real life applications of the content. The main aim of group presentations was to bring together ideas that could be used for portfolio assessment. It was noted from these group presentations that groups had some ideas in common. For example, on the objective 'simple money calculations' all groups talked about shopping - buying and selling situations such as shopping, budgeting, organizing tuck-shops, and hire-purchase. With regards to the second objective, groups came up with ideas relating to electricity or water bills, relationships between demand and supply, and writing a recipe. All three groups came up with ideas which were relevant to real life applications and proposed that these ideas or activities could be used for student portfolio entries. It was noted that two of the groups proposed written tests as one of the portfolio entries for the subtopic "rates". Since all the groups had already developed their ideas into teaching and learning activities, the next major challenge for us was to decide on how many entries would go in the portfolio and which entries would be selected. Groups' ideas are summarized in the table below.

Learning Objective	Group 1	Group 2	Group 3
Perform simple money calculations	Hands on activity -Advertisements-newspaper cutting (discount) -Shopping list – price list given by teacher, total cost calculations -Budgeting	Organize tuck-shops	- Prepare shopping list - Activity of hire purchase - Activity on budget
Understand and apply Proportionality	Electricity/water bills (assignment) VAT 15% apply in real life	-Relationship between price and demand - Relationship between height and mass (BMI)	-Activity on enlarging a photograph -Write a recipe
Identify and apply Ratios	-Student-teacher ratio in all subjects -boys-girls ratio method: investigation	-Written test Bring a cake and divide into pieces (fractions) also teach about ratio of boys and girls in class	-Write a simple recipe -Written test
Calculate percentage of a quantity Express one quantity as percentage of another	Hire purchase-agreement, newspaper cutting, deposit, installment (assignment)	Personal budget Personal budget (pie chart)	-Prepare a pie chart for family budget

Table 2: Teaching and Learning Activities

Finalising Portfolio Entries

The teachers decided that that it would be better if each group looked at certain sub-topics and made recommendations. Group one chose simple money calculations, group two chose proportions, and group three chose ratios. From whatever they had already done, it was now time to finalise the teaching and learning activities that would go into their student portfolios.

Group one worked on finalising activities on simple money calculations. This is what they had decided would be used as teaching resources or assignments:

> *Our group is working on developing activities on simple money calculations. Our first activity is on hire purchase. We will give our students newspaper cuttings of hire purchase and they will work out how much they will pay if they buy on cash and how much will they pay if they buy on hire purchase…and which mode of buying is better. They can also be asked to discuss why many people still use hire purchase mode of buying even when we know that it costs us more. We suggest two similar activities. One can be done in class; the other can be done as an assignment. Our next activity is again on percentages. This time our activity focuses on percentage of students who travel by different modes of transport to school…for example, what percentage of students come by bus, car,*

etc…We will again have one class activity and one assignment activity. (Gavin, group one)

It was interesting to note how the discussions were leading towards a transformation of their teaching and learning. The teachers now were moving away from a focus on text-book type exercises and writing more real life and relevant activities for their class. They even discussed about involving students in real data collection. The following conversation with group one revealed that teachers had not previously used such teaching and learning activities:

Researcher: Have you previously used these kinds of activities?
Isha: No…it's normally from the text book.
Researcher: Are these ones different from the text book ones?
Isha: No, it's similar ones…but this time it will be more practical like we will give our own numbers.
Researcher: So you will provide them with the numbers?
Isha: Yes, we will give how many students come by which transport.
Ana: We can also ask students in class to find out who comes by which type of transport.

Group two had developed similar activities on percentages, proportions and ratios. They produced more than one activity so that students will have an option to choose which learning activity they wanted for their portfolio. Both groups one and two included marking criteria for each of the activities they had proposed. The third group decided that there should be a sub-topic test on rates. They described their test as having simple calculations on rates and then moving onto application questions such as finding the rate at which a typist is typing and how much time will she or he take to complete a paper of certain length. When asked about the appropriateness of a written test for a portfolio, the group seemed to show an understanding that written class tests could be used in a formative manner. The following conversation with group three is noted:

Researcher: What is your group working on for your portfolio entry?
Bhim: We have developed a short test on rates.
Researcher: How you want the test to appear in student portfolio?
Bhim: Students will submit their test paper…and they will do all the corrections.
Researcher: Is that all?
Bhim: Students could also highlight areas which they have not understood well…even after doing the corrections.

Overall, the teachers showed a good understanding of portfolio assessment as the workshop was coming to a conclusion. This could be seen in their choice of real life application tasks, the idea of having more than one task on each learning outcome, and their suggestions of involving students to reflect on areas of the content which students might not understand. The fact that they were working on more than one item showed that they understood the need for children to be able to select some entries from the whole classroom work. Teachers showed great interest in changing their teaching styles to use more real-life based activities. They also suggested that students be engaged in individual work as well as group work. It could also be noted that teachers kept in mind the realities of their classroom. They did not support ideas that could not be easily handled. An example of such an idea was that of modeling a tuck shop in the classroom. Teachers generally agreed that it would create unnecessary chaos in the classrooms. Involving students directly in money transactions would also mean some resistance from the school administration and also from parents. In summary, based on the data reported here, we

speculate that, when provided with support, mathematics teachers did accept the idea of portfolios as a means of assessment.

Teachers' Reflections on the Usefulness of Professional Development

At the conclusion of the second day of the workshop, the ten teachers who were present were asked to reflect on the professional development workshop using the following prompts: *Reflect on the past two days of workshop. What did you find useful? What was not useful? What else could have been done? Do you have any other general comments?* Teachers' oral reflections were videotaped and transcribed. These post workshop reflections revealed that all the teachers had found the workshop very useful and relevant. The reasons for usefulness were mostly in terms of learning a new form of assessment. Teachers spoke in favor of portfolio assessment and how they and their students could benefit. Parts of their reflections are noted below:

> *In this two days' workshop, we learnt something new, something different. Portfolio assessment can help us to implement interactive teaching. What we do now is to teach from the textbook. A lot of strategies we learn is not only for this topic but could be used for other topics in mathematics as well. If we implement this in year 9, it would be good because if year 9 is stronger, we can good mathematics in upper forms. (Bhim's post workshop reflection)*
>
> *Two days workshop was fruitful for me. We learnt about teaching learning process. We designed activities for year 9 mathematics. These activities will be used to help young learners comprehend the topic well. I have learnt a lot. For example, the effort from the teacher, the effort from the students should be balanced. The students should like mathematics. That depends on how we teach. Using portfolio assessment in our teaching, we should motivate the learners. (Harris's post workshop reflection)*
>
> *Our teaching is restricted to classroom teaching. We learnt that mathematics teaching is more about students. We do a lot of procedural teaching, giving formulas and cramming. Now we can expand our work using real life based activities. Portfolio assessment provides a chance for us to include more interesting stuff in our teaching. (Harris's post workshop reflection)*
>
> *This workshop was very helpful- most parts were enlightening and useful. Changing times need changing techniques. Ranking a student with just a mark is not right. There is a variety of things we assess students on. Portfolio assessment provides one way to implement various forms of assessment. As long as we sit with one idea, we do not want to think outside the box. This workshop has given us an opportunity to think outside the box. (Gavin's post workshop reflection)*

The other teachers' reflections were similar in that all of them asserted the usefulness of portfolio assessment, not only as a means of new assessment but also as a way to change their teaching and learning so that students learning could be at the center of everything they did. Teachers admitted that their current methods of teaching and assessment were limited. For example, as noted in Harris's reflection, many teachers taught using a transmission approach to teaching that encouraged mere cramming of formulas and procedures, rather than focusing on mathematical processes. They also saw how the activities developed as part of portfolio assessment could be used to transform their teaching. Some agreed that portfolio assessment would provide an alternative means of assessment. When asked what else could have been done

in the workshops, teachers gave suggestions such as "more sessions like this, even for higher forms" (Fran); students views could be taken, whether or not they want the new form of assessment (Jenny); more teachers to be included (Jenny); making proposals on this to the ministry so that something like this could happen (Bhim); and, mathematics planners to be included so that they could talk to us (teachers) (Gavin). These suggestions indicated a certain degree of support for new ideas such as portfolio assessment and that these teachers were serious about engaging in professional development which is relevant to mathematics.

Conclusion

The aim of the study was to explore the possibility of working with secondary mathematics teachers to develop and implement a new form of classroom assessment in Fijian classrooms. This study viewed professional development of mathematics using the sociocultural lens. While the Fijian mathematics teachers usually do not experience such communities of practice for developing alternative assessments and this study ambitiously aimed to create some awareness in this regard, the findings tentatively point to the potential of portfolios as a means of assessing students' mathematical knowledge as well as providing a means discussing how to move away from the traditional teaching styles that focus on recall of information to more profound ways that tap on higher domains of mathematical proficiency. The findings agree with that of the Webb (2011) on how teachers initially encounter challenges in developing tasks that align with higher-order real world mathematics. In addition, there is evidence in support of the claim that allowing for professional learning of mathematics teachers on the topic of portfolios opens up space for talking mathematically not only about assessment, but also about how to make mathematical learning more meaningful to the learner. The current intervention was unique in the sense that it focused specifically on portfolio assessment.

The data generated from the two − day workshop with mathematics teachers provided useful insights into how to develop guidelines for portfolio assessment in mathematics. The findings indicate that teachers were able to accept the idea of portfolios as a means of assessing student learning. In addition, they were also able to develop possible teaching and learning tasks to be used as assessment options. The overall idea of portfolios provided teachers an opportunity to talk about higher-order application tasks that promoted the idea of learning mathematics in context. Most of all, the workshop provided an opportunity to see firsthand how Fijian mathematics teachers reacted to a new idea, given that mathematics educators generally are aware that it is not good to just transplant a policy or practice from one context into another and expect to repeat success (Brown & Liebling, 2014).

With respect to conceptualisation and development of portfolio assessment in mathematics, this study regards the following steps to be helpful in terms of designing professional development for teachers: Deciding on a purpose of the student portfolio assessment; outlining the mathematical content and processes; developing rich learning tasks; and, finalizing portfolio entries. While the three broad concepts in portfolio assessment that included conceptualization, development, and grading of a portfolio (Klenowski, 2002) seem appropriate for general development of portfolios inside a classroom, the current study's focus was slightly different because it involved professional learning on how teachers could design a portfolio assessment that could be used in a mathematics class.

Deciding on the purpose of the portfolio is a relatively simple yet valuable exercise. Learning from the current study, teachers agreed that the overall aim of the 'unit 'could become our major purpose of portfolio assessment. That purpose was then kept in mind throughout the development phase. The next thing to do is to engage teachers to re-look at the mathematics they are teaching. They need to align the content with the appropriate mathematical ideas or processes. When students learn content, they are also learning important processes such as solving, designing or exploring. The idea suggested by Klenowski (2002) is for teachers to have a thorough understanding of how learning is going to develop in relation to the content which is at hand. Giving teachers an opportunity to think of mathematical processes will allow them to come up with better teaching and learning ideas. The key component of the professional development is the third item – developing rich learning tasks. Rich tasks mean tasks which allow students to use or apply high-order mathematical processes. These tasks, when well designed, will allow for a formative assessment culture to slowly get established. Once teachers have developed good tasks, they could then finalize the portfolio entries by providing a guideline as to what is to be expected in the portfolios. The intervention programme reported in this study was generally found to be useful by our participant teachers. The researchers are of the view that more research would be required to ascertain how other Fijian mathematics teachers view the idea of portfolio assessment, and how teachers would make use of student portfolios in the mathematics classroom.

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