2007/2008, Vol. 9, 66–80 *Mathematics Teacher Education and Development*

Addressing Changing Assessment Agendas: Impact of Professional Development on Secondary Mathematics Teachers in NSW

John Pegg and Debra Panizzon
National Centre of Science, Information and Communication Technology, and Mathematics Education for Rural and Regional Australia (SiMERR), University of New England

In New South Wales the focus on assessment *for* learning requires teachers to consider carefully the alignment between assessment, curriculum, and pedagogy. This emerging agenda in teacher education seeks to ensure that assessment practices provide advice to teachers about what students know and where teaching might be directed to enhance learning. To incorporate this change into classroom practices, teachers need ongoing and sustained professional development. This paper describes the experiences of secondary mathematics teachers as they engaged in a two-year professional development program using the SOLO Model as the theoretical framework to explore the changing nature of assessment. Initially, teachers' views of the advantages of the professional development experience are identified as major themes. Following this overview, three case studies are presented to provide a longitudinal perspective about the ways in which the views of teachers evolved over the period of the project.

International educational interest is moving towards developing better, and expecting more of assessment practices (Black & Wiliam, 1998). "Not the kind of assessment used to give grades or to satisfy accountability demands of an external authority, but rather the kind of assessment that can be used as part of instruction to support and enhance learning" (Shepard, 2000, p. 4). This emerging agenda challenges traditional assessment practices (Linn, 2000) and has become a primary focus in New South Wales (NSW) with a move towards assessment *for* learning (Board of Studies, 2003). For many teachers this agenda has required a major shift from the traditional summative view of assessment to one that is more closely aligned to identifying and interpreting students' understandings along a continuum of learning (Board of Studies, 2003).

The emphasis on embedding assessment into the teaching and learning process is identifiable globally with such research initiatives as the King's-Medway-Oxforshire Formative Assessment project (KMOFAP) in the United Kingdom (Black & Harrison, 2002; Black & Wiliam, 1998) and the Berkeley Evaluation and Assessment Research (BEAR) Assessment System at the University of California in the United States of America (Stiggins, 2002; Wilson & Sloane, 2000). Both of these projects involve researchers working with science and mathematics teachers and have been operational for a number of years. Of particular interest is the project by Wilson and Sloane (2000) that was developed specifically around four principles seen to be lacking in other assessment programs in the United States of America, including:

- a match between teaching and assessment;
- teacher management and responsibility;
- quality evidence; and
- a developmental perspective of student understanding.

In addressing these principles, the projects mentioned above share two common features. First, although research-orientated, provision of sustained professional development for teachers was a critical component of the designs. Not only does this facet ensure that teachers 'take charge' of their own growth and development, it increases the likelihood of engendering a high degree of ownership and commitment over a longer-term (National Research Council, 1996; Ramsden, 1992; Zuber-Skerritt, 1992). Longevity is seen as crucial to initiate changes in personal attitudes and beliefs necessary if teachers' pedagogical practices are to alter substantially (Cooney & Shealy, 1995). In the context of the current project, it was considered particularly challenging to move mathematics teachers from a norm-referenced to criterion-referenced perspective in order to embrace the assessment for learning agenda in NSW (Board of Studies, 2003).

Second, the same theoretical framework guided both projects, namely the Structure of the Observed Learning Outcome (SOLO) model developed by Biggs and Collis (1982, 1991). Essentially, SOLO is concerned with specifying 'how well' (qualitative) something is learned rather than 'how much' (quantitative). It is the mental structure of the understanding that is important, and the criteria are merely examples, which are typical of the types of levels of performance. The exact nature of these examples varies depending on the different learning experiences and activities or on the background experiences students bring with them. This supports the notion of social and contextual constructivism in which students' understandings are influenced by their learning environment (e.g., Ernest 1992), as well as language impasses related to learning experiences (Zevenbergen, 2001).

This qualitative approach represents a departure from the testing of skills, facts and learnt algorithms or procedures in the traditional sense. It is in the area of measuring the quality of cognitive assimilation in terms of progressive structural complexity that SOLO has its main strength. Consequently, it has been a valuable tool for research into: students' understandings in many specific topic contexts (e.g., Coady & Pegg, 1996; Cuthbert & Pegg, 1993; Panizzon, 2003; Pegg, 1995; Reading & Pegg, 1996; Watson, Collis, & Campbell, 1994; Watson, Collis, Callingham, & Moritz, 1995); curriculum development initiatives (e.g., Pegg, 1995; Pegg & Panizzon, 2001); and ways to assist teachers with assessment issues in their classrooms (e.g., Collis & Romberg, 1991, 1992).

The project, discussed in this paper, concerns teachers applying SOLO as a framework to underpin new assessment practices in the classroom. The overarching aim of the project was to empower teachers to apply theoretically-based knowledge concerning the structure of students' understanding so that their assessment and teaching practices could become better aligned. In this paper we focus on the professional development component providing an overview of the reflections of teachers as to the gains made over the two-year period.

The Developmental-based Assessment Project

The Developmental-Based Assessment (DBA) project was devised to explore teachers' applications of assessment techniques in their own classrooms. It arose directly from the changing assessment practices required to satisfy the requirements of new syllabus documents introduced into NSW in 2000.

Specifically, it was anticipated that the project would:

- provide teachers with a balance to more traditional approaches of assessment that are usually concerned with how much has been learned by the student;
- assist teachers to focus on what has been understood rather than what has been remembered;
- introduce teachers to the notion of the quality and nature of the learned outcome by exploring the structure of students' understandings; and
- help teachers take the information gained about student learning and understanding and use it as a basis to provide an improved learning environment for their students.

This approach has clear appeal for many educators especially if one takes the philosophical stance that a primary purpose of assessment is to provide support for teaching techniques that can improve learning.

Participants

Twenty-five teachers (13 science, 12 mathematics), representing six secondary coastal and inland schools participated in the project. Both Catholic and Government schools were included in the sample (three of each). Within each school there were at least two teachers working in the same area in each school (e.g., secondary mathematics). This structure ensured that teachers did not feel isolated when they returned to the school and were able to work with at least one other member of staff. It also allowed teachers in the same discipline area to share resources and ideas.

Design

In developing the design for the two-year project, research by Clarke (1994) and Garet, Porter, Desimone, Birman, and Yoon (2001) were considered. Subsequently, three fundamental components were included in the design, namely: (i) a focus on academic content and rigour; (ii) an opportunity for hands-on experiences and active learning by teachers; and (iii) an emphasis on tasks and activities with high applicability to the classroom.

The project was funded for two years. In the first year, a series of three, two-day workshops were conducted at the university. These allowed participants to be removed from the normal work environment and their day-to-day responsibilities. Additionally, the researchers visited the teams of teachers in each school to provide an opportunity for them to demonstrate their work within their own teaching context. Funding for the project allowed release time for teachers to be covered during their absence from their school and opportunities for teachers to have some time to devote to the project during normal working hours. An overview of the program for the first-year is provided in Table 1.

Table 1
Timeline for the first-year of the project

Month	Instructional activity
February	Initial 2-day workshop at the university. Introduction to SOLO Model and issues relating to assessment identified by teachers. Review of current assessment theories and agenda in NSW. Assessment strategies explored and discussed.
March to May	Ongoing access to professional expertise to maintain momentum of the aims of the project and facilitate teacher growth through the concepts covered at the meeting in February.
June	Interim 2-day workshop at the university. Review of the model. Report back on work undertaken with students insitu. Discussion about emerging assessment issues.
August to September	On site visits to each school and faculty group by the project team to discuss concerns, programming, and assessment tasks and strategies.
November	Final 2-day workshop at the university to discuss progress to date. Report back by each group of teachers regarding their successes and failures regarding assessment. What worked? What did not? Why? What are the emerging issues? How can these be counteracted?
	Planning for the second year based on participant experiences of the first year of the program.

The first year of the program was designed to be flexible, enabling teachers to make contributions to the workshop sessions. To achieve this but still provide adequate direction, the initial workshop was fully organised and prepared for presentation based around new approaches to assessment and the theoretical framework of the SOLO Model.

At the culmination of the February workshop, teachers provided input in two areas. First, they identified the kinds of activities they would explore with their students during the March-to-May period. Second, they specified the types of input they required for the June workshop. For example, one team from a school close to the university requested a series of monthly two-hour after-school sessions. These needs were clarified and refocused as the teachers became more familiar with the program and the SOLO Model. Similarly, teachers were able to select their own 'course of action' for the August to September period by negotiating with the project team. Consequently, teachers had a high degree of

ownership of the project in terms of the focus of workshop sessions and school group activities.

At the final workshop meeting in November of the first year each group of teachers decided on individual school plans for the second year of the project by negotiating with the project team. This ensured that the particular needs of teachers in specific schools were met.

In terms of the second year, each of the six schools developed a distinct program with support from the research team. For example, in one school the science teachers planned to use the SOLO Model to develop a rubric for assessing science research projects (i.e., first-hand investigations). In another school, mathematics teachers chose to develop closed assessment items that allowed them to quickly identify students' levels of response. These items could be incorporated into topic tests and used to assess student understanding of mathematical concepts. During this second year, teachers were brought together to share their experiences on three separate occasions. A large component of this sharing included a review of the assessment tasks produced along with examples of students' responses.

In addition to the design outlined above, ongoing consultative help was available for the teachers between workshop sessions during both years. This was provided in a number of ways including the help of a part-time project officer, phone calls to teachers in schools at specified times, and ongoing electronic access to the project Web page.

Overall, every attempt was made for the project to be sensitive to and reflective of the wishes and needs of the participants. Within the constraints of the budget, every attempt was made to respond to a teacher's request for support. These included some (albeit limited) financial support to cover teacher relief, information and advice through the provision of articles and Web materials, discussions with peers from other schools through telephone, emails and chat rooms on the internet, and school visits by members of the project team.

Data Collection

There were two primary sources of data collection for the project. These were: (i) teacher perspectives and experiences with DBA, and (ii) student scripts coded using the SOLO model to inform developmental pathways of knowledge acquisition within topic areas in mathematics and science. This paper is concerned only with data collected on mathematics teachers' perspectives of the DBA project.

Data from teachers were gathered during each of the workshops from three different sources. Initially, teachers completed compulsory questionnaires developed for evaluation purposes by the Quality Teaching Project (QTP) organisers. The Likert Scale questions related to: participant satisfaction with the professional development activity; the degree of learning gained from the experience; and the extent to which participants believed that their behaviour was modified or influenced by the professional development experience. In addition, each of the workshop sessions was taped and later transcribed with the approval of all participants. As different components of the workshop sessions

were highly interactive, this provided a rich pool of qualitative data. Finally, interviews were conducted with teachers on three occasions throughout the two-year period: (i) at the end of the first six months of Year 1; (ii) at the completion of Year 1; and (iii) at the end of Year 2.

Results and Discussion

The results presented in this paper focus on teachers' reflections of the professional development opportunities provided as part of the DBA research project. Initially, an overview of the broad themes that emerged from an analysis of these data is presented. This is followed by three case studies that provide a longitudinal perspective allowing insights into the way in which each teacher's view changed or evolved over the two-year period of the project. To ensure anonymity for the teachers and schools involved, pseudonyms are used.

Overview of Teachers' Reflections of DBA

A number of themes emerged in relation to professional development and the way it initiated changes in teachers' assessment practices. Each of these is identified in Table 2 along with a synthesis to encapsulate the comments provided by teachers.

Table 2
Overview of teachers' perceptions of professional development in DBA project

Theme	Synthesis of teachers' comments
Relevance	Assessment was recognised by teachers as being a 'high priority' area in the current climate in NSW. They recognised a need for changing their assessment practices from a summative focus to one that embraced assessment as a means of informing students about their progress in terms of understanding while helping teachers to provide activities and experiences to meet the needs of students.
Choice and flexibility	As contexts altered between schools, teachers were cognisant of the need to be able to develop and implement assessment strategies relevant to their teaching situations. Therefore, choice and a high degree of flexibility in the assessment focus selected were critical in meeting their needs. Ultimately, they felt confident in setting their own goals resulting in a high degree of ownership of the project.
Shared experiences	A team approach ensured that each teacher had a partner in the school to share ideas, experiences and resources. Within the school this helped to keep the momentum between formal workshop sessions. On a

	broader scale, being able to compare assessment tasks and views with teachers outside of their own school provided an opportunity for 'benchmarking' their standards with their peers. This was perceived as critically important for teachers given their regional and rural location in NSW.
Convergence of theoretical knowledge and application to the classroom	Utilisation of the SOLO Model supported the inclusion of learning theory. Teachers acknowledged that this theoretical input provided a foundation for them to reflect upon their assessment tasks, strategies and classroom teaching practices. Development of a task for each group of teachers ensured that they were able to apply theory into their own practice. Subsequently, these experiences provided extensive discussions during the next workshop sessions.
Development of discipline content knowledge	Critical to the project was a rare opportunity for teachers to engage in discussion about mathematical content at a conceptual level. This usually emerged from analysis of students' responses in trying to identify their underlying thinking processes. Discussions of this type identified for many teachers the need to consider carefully the types of questions they gave their students. Teachers recognised that particular styles of questions may be advantaging some students over others.
Length of project	Sustained professional development was a new experience for teachers. Although daunted initially by the two-year commitment, they recognised that this length of time was necessary to initiate the changes in their own beliefs and ideas about assessment.
In-school support	Financial support in the form of release time to work on the project was critical. Essentially, it provided teachers with the 'work space' necessary to consider students' responses and prepare for subsequent workshops or team visits to the school. Approval from the senior executive and other members of the mathematics department was also necessary if teachers were going to have the freedom to trial different assessment strategies within their classrooms.
Reflection of experiences	Being able to reflect on practice and share this with others was fundamental to ensuring teacher involvement in the project. This occurred both within the schools and during the formal workshop sessions.

These themes and descriptions reflect the principles identified by Clarke (1994) and Garet et al. (2001). It is clear that teachers considered the program provided the theoretical background and mathematical content knowledge they required so as to:

- provide a 'hands-on' approach, encouraging and supporting teachers as they implemented ideas and strategies in their own classrooms;
- allow teachers to evaluate the effect of these strategies and changes on student learning and engagement in a 'safe' environment; and
- facilitate sharing across schools, allowing teachers to gain from the experiences of their peers.

Interestingly, although the length of project was perceived initially as "daunting", ultimately teachers recognised that it was necessary to ensure the sustainability of change in the longer-term. Many of these themes are reinforced below within the contexts of the three case studies.

Case Study 1: Andrea

Andrea was a highly experienced mathematics teacher with many years of teaching experience in the same, relatively small rural school. Her teaching load changed during the project from full-time in Year 1 to five days per fortnight in Year 2. Andrea's teaching focus was to ensure that students developed basic skills in mathematics so her role was to help establish a solid basis for life-long learning. Andrea was particularly interested in supporting and building up the self-esteem of students.

After six months

Our biggest problem in trying to implement ideas in the classroom was time.

It was hard to get together and code responses and write questions to get a variety of responses. The crowded curriculum is overwhelming, and it makes it hard to cover all the bases; often other things take priority. At the beginning, the terminology of the model was unclear. Perhaps there is a need for a basic model for beginners.

Can we have a chart with clear definitions on hand to help write items and code students' responses?

I can see that using the model will help as a reporting tool in terms of the justification aspect.

End of Year 1

The acquisition of new skills with assessment has been an even slower process, and I did not feel, take place until very late in the year. [Writing questions] took some time, and I did not get time to do coding on all questions attempted. The broader the question was the harder it was to code using SOLO.

I was 'softer' on my kids, so it was good to be working with others who could be more objective in terms of assessment. In the end we all pretty much agreed on where to code each response. On the few occasions we argued, we all understood because we all used the same language.

Interaction with peers helped me to feel more comfortable with coding, I struggle on my own. It has changed my perspective on some of my kids; the poor kids can actually do better than I thought. Knowledge of SOLO is a powerful tool.

Coding responses for a particular topic can change or improve how it is taught the next time. Next year I would like to refresh and renew what I have learnt this year, and develop a more informed understanding. Next year I would like to have more time to discuss the process with other teachers from my school and other schools. Can we have half/day sessions at UNE next year, and more release time?

End of Year 2

It is only now that I realise the impact the experience has made to my teaching and assessment practices. I have become aware of so many aspects of my teaching that although I knew was good practice, you just need to be able to reflect on this for periods of time.

A major advantage this year was the opportunity for release time so that we actually had time to think about the ideas provided during the professional development sessions. Changing a mindset really does take a period of time and doesn't happen overnight.

I now feel ready to discuss what we have learnt with other members of the faculty who are very interested for us to explain the reasons behind the changes they have noticed in our practice.

While I still do not feel strong with coding using the SOLO Model, it has provided me with the necessary background to what I do in the classrooms. So many things make more sense — I have an understanding about what I see happening!

Case Study 2: Peter

Peter was an experienced mathematics teacher in a large secondary coastal school and coordinated a department of ten mathematics teachers. He exhibited a passion for the subject and for the well-being of his students. Peter was concerned that his students enjoyed mathematics so was keen to implement novel and creative questions into his teaching.

After six months

I was interested from the first workshop. It has given many insights into the frustration of teaching a different generation of students to the ones I first started teaching over 20 years ago. The youth of today have far different demands and I am confident that this professional development will help me to meet these demands. I would benefit from some quiet study of the material presented to lower my 'working memory.' I am always focused around what am I going to do with this knowledge when I walk into a classroom tomorrow?

I have trialed some questions. I used some questions to help with Year 7 grading at the end of Term 1, but didn't get around to coding them properly. I trialed some questions in the Year 8 exam, and some of the other teachers commented

on the 'different style.' They were concerned that some of their 'bright' students might not do so well. In the end, the brightest students did not necessarily give the highest responses.

Can we have a visit from the Project Team to [our school]? Can the [successfully coded questions] be put on the web? How can I use [this knowledge] to grade my students successfully? I am applying SOLO to different subjects. Now I need to learn how to give the students more time in the classroom to progress through the levels.

End of Year 1

I gave a question about how many ping-pong balls would fit into my classroom. I gave no other instructions. The students were really motivated — some didn't even stop for lunch. They went about it in so many different ways. One girl took pages of words to explain her answer. One boy just gave some calculations. They both ended up with the same answer.

This has been really critical — that is being able to develop and try things relevant to our own school. At first I thought we would not have this flexibility — also perhaps I was a bit surprised that the project team was not more directed in what they wanted. But now I am appreciative of this — ensures that it is applicable to each teaching situation.

It was helpful having the project team come to [our school] to help code these. SOLO helped me to reconcile the use of different types of responses. Other teachers are asking, "Why are students being asked to explain more?" They are curious; they see a change in my students (attitude). I have a different atmosphere in my classroom. It has changed the way I teach different topics. I now spend 'real time' preparing lessons. I want to be kept up-to-date next year, regular email contact? Can I involve the rest of my staff?

End of Year 2

At the final meeting of the project for the year, Peter reported that he had devised and tried many questions with various classes. He seemed to enjoy sharing successes and failures with other participants in the project.

At this point I now feel that my classroom practices have really taken onboard what we have been discussing over the last couple of years. My view of assessment has changed in many ways, but most importantly I realise that what I gauge in class about student understanding helps me think about what I should be doing in regards to teaching next lesson.

This whole process hasn't been easy because there are so many demands on teachers in their day-to-day school environment. But having time provided by the team to allow us to work together and focus on activities and reflect about what we have been doing has been crucial.

Having experienced the professional development provided with this project, it makes me realise how short-term a lot of the other programs have been. It just takes time to engage teachers and get them to actually put change into practice — and they need to have support in the schools as well. Luckily I am in a position to support staff because I am coordinating the maths department here.

Case Study 3: Sophie

Sophie was a qualified mathematics and physical education teacher with experience in both urban and rural high schools. She also had some experience as a head teacher in both of these subject areas. Sophie was concerned that all students in her mathematics classes experienced a degree of success as she considered that this helped to build their self-esteem. At the time of involvement with this project, Sophie had a young family so found it difficult to allocate out-of-school time to the project.

After six months

My questioning style has improved in order to draw information from my students. I was involved with marking [commercial tests]. They mainly ask students [for facts], not deeper understandings. I tried some text book and published questions, but they were too ambiguous to get SOLO responses in coding responses.

There is too much pressure to get the same coding result as you. I am anxious to apply this more in the classroom because I want it to help grade students. We need deadlines at regular intervals. We need a package of sample questions. I want some questions to try, can we take some home? Can we use school visits to code things?

End of Year 1

I tried a question on factorisation because I could see a problem in class. Something wasn't 'clicking.' The results showed a gap in their understanding, so I retaught that section. I have used more guided questioning. I've used questions to gain a deeper insight into students' understandings. I've tried to spend some time on matching exams to the Course Performance Descriptors.

It is really good being able to come back to this group and share our experiences with people who understand what we are on about. It also keeps us on track in terms of what we should be doing.

Critical for me has been the ongoing access to consultative help either from Mary [project officer] or from the project team. If not for this I am sure I would not have been able to stay with the project.

Can we have an item bank of questions? Can we liaise with other schools, especially for item bank questions? At the next meeting can we all share tasks we have developed, and see how SOLO matches Year 10 assessment demands, and how it can help with reporting?

End of Year 2

I have really liked the practical ideas that I have been able to implement in my classrooms. Often this is not the case with research projects.

The notion of engaging in a professional development program over 2 years just overwhelmed me to start with but I can see now that it is kind of necessary when I think about the changes that have been made since we began.

> You know this project has done more than change assessment practices — it has impacted many of my teaching practices like questioning, the kinds of activities I use in class. For example, I reflect a lot more about which are the best activities to use and why in terms of what I want students to learn! So it broader than assessment — I suppose that is the whole point — assessment is only part of what we do!

> Another aspect of this program that just struck me the other day is that this is the first time in ages that I have actually thought about mathematics as a subject and about my own understanding. With the examples used during our workshop sessions and when the team visit has provided me with an opportunity to reflect about my own content knowledge and understanding. Too often professional development does not include discipline content at all!

In considering these case studies major changes are identifiable in teachers' foci over the two-years. Initially, Andrea and Sophie were interested in coding students' scripts using the SOLO Model and identifying problems with this process given the constraints of time. However, over the next period of the project they recognised the impact that knowledge of the model and other learning theories were having on their classroom practice. In contrast, Peter appeared to be more relaxed and was comfortable to trial strategies in his classroom and observe the outcomes. This confidence remained throughout the project as he used the experiences gained from the workshops to explore his own views of teaching and learning.

These differences may reflect the various positions held by teachers in their school, the influences on their life outside of school, or their teaching priorities. Alternatively, they may highlight the different learning styles that individual teachers bring to any professional development program. While there is often discussion in the literature directed at the importance of meeting the varying needs and expectations of students, teachers are often perceived as being a homogeneous group. Subsequently, professional development programs are often structured so that one approach is expected to suit all. Clearly, the data from this small sub-sample demonstrates that such a simplistic assertion is inappropriate.

Having considered the differences, the three case studies highlight a number of commonalities that were identified by the other mathematics teachers involved in the project. For example, all teachers felt constrained by time and their day-to-day teaching responsibilities within their schools. While they appreciated the teacher relief provided during the project, they were cognisant of the need for a balance to be maintained between the teacher's workload, the research team's workload, the funding available, and school restrictions on time away from classes. However, despite this, teachers stressed that time-out was essential to reflect, to plan, to meet, and to practise new ideas.

Still in relation to time, the most noticeable change in teacher practice occurred between twelve to eighteen months into the project. It was at this point that changes to teachers' practices regarding assessment became more evident. Not only were there identifiable changes in the assessment tasks set but also in the way teachers spoke about assessment. For example, discussions about

assessment moved from being focused on summative, end-of-topic tests to the importance of gauging student understanding on a daily basis. Teachers recognised that this continuous assessment (i.e., formative) allowed them to consider the types of activities and experiences needed by their students to enhance their learning. In other words, they had embraced an assessment *for* learning perspective (Black & Wiliam, 1998; Board of Studies, 2003). However, this highlights a serious problem in terms of the length of time provided for the majority of professional development programs (Cooney & Shealy, 1995).

In terms of the theoretical focus of the project, all teachers spoke about the impact of the SOLO Model on guiding their thinking and classroom practice. While somewhat sceptical of the inclusion of 'theory' at the beginning, teachers reflected positively on the value of the model and its impact on their teaching. Furthermore, by the completion of the two-year program teachers recognised the need for other teachers in their mathematics department to become familiar with the model. Interestingly, they were also keen to take a role in the professional development of other staff.

In summary, the design of the project ensured that the process of professional development was an active one, thereby allowing teachers to negotiate the kinds of problems and issues around assessment they were keen to explore. Teachers were able to work with their students within their normal classroom environment, utilising the knowledge acquired from their involvement with the project. In the long-term, this provided a sense of 'ownership' and a willingness to continue their involvement. The need for ownership has been found to be one of the most crucial components of ensuring the commitment and likely success of educational professional development projects (Clarke, 1994; Ramsden, 1992; Zuber-Skerritt, 1992).

Conclusion

The results described in this paper have provided valuable insights into the experiences of secondary mathematics teachers involved in a professional development program to apply a theoretical model to improve their assessment practices in the classroom. Clearly, the DBA project helped teachers address the assessment *for* learning agenda underpinning syllabus requirements in NSW. However, this required a major shift for them from viewing assessment as an activity that occurred at the end of a topic, to one that was used on a day-to-day basis to enhance student learning. In this manner, assessment practices evolved to become embedded with curriculum and pedagogy.

Teachers were positive about the professional development program provided in the study. It allowed teachers to set goals relevant to their own teaching contexts, generating a high degree of ownership and commitment to the project. They valued the opportunity of sharing with peers from other schools in a collaborative and engaging manner. However, this required an extensive period of time with major change identifiable between twelve to eighteen months. This is a critical finding if change in teacher practice is to be sustainable over the long-term.

Acknowledgements

The professional development program identified in this paper was funded by a Quality Teaching Project while the research agenda was funded by an ARC Discovery Project DP0345634.

References

Biggs, J., & Collis, K. (1982). *Evaluating the quality of learning: The SOLO Taxonomy*. New York: Academic Press.

Biggs, J., & Collis, K. (1991). Multimodal learning and the quality of intelligent behaviour. In H. Rowe (Ed.), *Intelligence: Reconceptualization and measurement* (pp. 56-76). Melbourne, VIC: ACER.

Black, P., & Harrison, C. (2002). Assessment for learning in science classrooms. Paper presented at the National Association for Research in Science Teaching, April 1-5, 2002, New Orleans, Louisiana.

Black, P., & Wiliam, D. (1998). Assessment and classroom learning, *Assessment in Education, 5*(1), 7-74.

Board of Studies (2003). Assessment for learning in a standards-referenced framework. *Board Bulletin, 12*(1), 4-5.

Clarke, D. (1994). Ten key principles from research for the professional development of mathematics teachers. In D. Aichele & A. Coxford (Eds.), *Professional development for teachers of mathematics*, National Council of Teachers of Mathematics 1994 Yearbook (pp. 37-48). Reston, VA: NCTM.

Coady, C., & Pegg, J. (1996). Levels of formal reasoning in high school algebra. In A. Gutiérrez (Ed.), *Proceedings of the 20th International Group for the Psychology of Mathematics Education* (2, pp.233-240). Valencia, Spain: University of Valencia.

Collis, K., & Romberg, T. (1991). Assessment of mathematical performance: An analysis of open-ended test items. In C. Wittrock, & E. Baker (Eds.), *Testing and cognition*. New Jersey, USA: Prentice Hall.

Collis, K., & Romberg, T. (1992). *Collis-Romberg mathematical problem-solving profiles*. Hawthorn, Victoria: ACER.

Cooney, T. J., & Shealy, B. E. (1995). *Teachers' thinking and rethinking assessment practices*. Paper presented at the Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Columbus, Ohio [ERIC document: ED389597].

Cuthbert, R., & Pegg, J. (1993). Strategies used by Year 9 students to solve problems on speed. In B. Atweh et al. (Eds.), *Proceedings of the 16th Mathematics Education Research Group of Australasia* (pp. 297-302). Brisbane, Queensland.

Ernest, P. (1992). The nature of mathematics: Towards a social constructivist account. *Science and Education, 1*, 89-100.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*, 915-945.

Linn, R. L. (2000). Assessments and accountability. *Educational Researcher, 29*(2), 4-16.

National Research Council (1996). *National science education standards*. Washington, DC: National Academy.

Panizzon, D. (2003). Using a cognitive structural model to provide new insights into students' understandings of diffusion. *International Journal of Science Education, 25*(12), 1427-1450.

Pegg, J. (1995). Perspectives on Year 9/10 advanced mathematics syllabus for N.S.W. (Keynote Address NEMA Annual State Conference). *In New Syllabus Directions — Secondary Mathematics: Proceedings of the 4th Annual Conference* (pp. 15-24). Armidale, NSW: New England Mathematical Association.

Pegg, J., & Panizzon, D. (2001). Determining levels of development in outcomes-based education: Nice idea, but where is the research-base for the decisions taken? Paper presented at the American Educational Research Association Conference, April 10-14, 2001, Seattle, Washington.

Ramsden, P. (1992). *Learning to teach in higher education*. London, UK: Routledge Press.

Reading, C., & Pegg, J. (1996). Exploring understanding of data reduction. In A. Gutiérrez (Ed.), *Proceedings of the 20th International Group for the Psychology of Mathematics Education* (4, pp.187-195). Valencia, Spain: University of Valencia.

Shepard, L. A. (2000). The role of assessment in a learning culture. *Educational Researcher, 29*(7), 4-14.

Stiggins, R. J. (2002). Assessment crisis: The absence of assessment for learning. *Phi Delta Kappan. 83*(10), 758-766.

Watson, J., Collis, K., & Campbell, K. (1994). Developmental structure in the understanding of common and decimal fractions. *Focus on Learning Problems in Mathematics, 17*(1), 2-25.

Watson, J., Collis, K., Callingham, R., & Moritz, J. (1995). A model for assessing higher order thinking in statistics. *Educational Research and Evaluation, 1*(3), 247-275.

Wilson, M., & Sloane, K. (2000). From principles to practice: An embedded assessment system. *Applied Measurement in Education, 13*(2), 181-208.

Zevenbergen, R. (2001). Identifying literacy demands of adult numeracy. *Literacy and Numeracy Studies, 10*(1/2), 39-53.

Zuber-Skerritt, O. (1992). *Professional development in higher education: A theoretical framework for action research*. London, UK: Kogan Page.

Author

John Pegg, National Centre of Science, Information and Communication Technology, and Mathematics Education for Rural and Regional Australia (SiMERR), University of New England, Armidale, NSW, 2351. Email: <jp`egg@une.edu.au>

Debra Panizzon, National Centre of Science, Information and Communication Technology, and Mathematics Education for Rural and Regional Australia (SiMERR), University of New England, Armidale, NSW, 2351. Email: <dpanizzo@une.edu.au>