Addressing Changing Assessment Agendas: Experiences of Secondary Mathematics Teachers in Rural NSW

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This paper describes the early experiences of secondary mathematics teachers in four rural schools in NSW as they began to explore the changing nature of assessment and the implications it has for their practice. Two important findings emerged from their involvement and experiences. First, teachers reported that using a theoretical framework to guide decisions acted as a catalyst to their rethinking of how and what to assess. Second, teachers used assessment information as a trigger for improving their teaching practices to enhance student learning.

Changes to the ways teachers traditionally assess students are a particularly challenging issue facing teacher education in a time of outcomes-based education. This new emphasis can involve identifying what a student knows and can do, and how this information compares with the standard expected by a relevant syllabus document (Assessment and Reporting Directorate, 1996; Board of Studies, 2003). Subsequently, teachers need to make "judgements, on the weight of assessment evidence and well-defined standards, about student progress towards the achievement of an outcome" (Assessment and Reporting Directorate, 1996, p. 226). In New South Wales (NSW), secondary teachers are required to engage in making decisions about the degree to which students have met particular outcomes so that they are positioned at a particular 'level of achievement' as specified by Course Performance Descriptors for a subject area.

Traditionally, assessment practices in NSW were determined using a quantitative approach. It concerned applying norm-referenced, summative tasks to test a student's ability usually resulting in a single numerical score. The results of this form of assessment are useful for certification and selection purposes because they produce a rank order of students based on 'ability.' Nevertheless, the procedures and results provide little insight into the degree of knowledge and understanding gained by the student (Pegg, 2003). As such, the approach is not particularly helpful for teachers and learners as it provides only superficial information for teachers (and learners) in terms of teaching directions that may best influence student learning.

In NSW, as in other States in Australia, there has been a shift over the last few years towards a more inclusive view of assessment. In this view there is the notion of "assessment of learning and assessment for learning" (Board of Studies, 2003, p. 4). This focus is identifiable also in the USA (Stiggins, 2002) and the UK (Black & Harrison, 2002). Within this context, assessment is viewed as being an important component of the teaching and learning process so that there is 'constructive alignment' of the three arms of curriculum: assessment, curriculum content, and teaching practices (Biggs, 1996). Hence, assessment is conceptualised as being intrinsically linked to what happens in the classroom on a day-to-day basis rather than something that occurs at the end of a mathematics topic.

Operationalising the new assessment agenda has been a significant part of the research effort carried out within the Centre for Cognition Research in Learning and Teaching at the University of New England. However, there are a number of projects being carried out internationally, which are based around similar work in teacher education. For example,

the Berkeley Evaluation and Assessment Center at the University of California has developed and implemented the BEAR (Berkeley Evaluation and Assessment Research) Assessment System over the last seven years (Wilson & Sloane, 2000). This assessment program is based around four principles seen to be lacking in many forms of assessment practice in the United States. These include:

- A developmental perspective of student understanding
- Match between instruction and assessment
- Teacher management and responsibility
- Quality evidence

A second major project is the King's-Medway-Oxfordshire Formative Assessment Project (KMOFAP) that set out to work within secondary science and mathematics classrooms to improve formative assessment practices (Black & Harrison, 2002). This project incorporated many of the findings and conclusions identified from a review of previous research in the area of formative assessment (see Black & Wiliam, 1998).

Interestingly, common to the two overseas projects and the one reported in this paper, is the reliance on the SOLO (Structure of the Observed Learning Outcome) Model developed by Biggs and Collis (1982, 1991) as the underlying theoretical framework. While the current project uses the most recent developments in SOLO (Pegg, 2003), the Berkeley project's "scoring guide uses a general logic (adapted from the SOLO Taxonomy; Biggs and Collis, 1982) …" (Wilson & Sloane, 2000, p. 192).

In terms of this project, the SOLO model provides a means of exploring student understanding from a developmental perspective. As such, it has been used in many research studies including: specific topic contexts (see Panizzon, 2003; Reading & Pegg, 1996; Watson, Collis, & Campbell, 1994); for curriculum development initiatives (e.g., Pegg, 1995); and, ways to assist teachers with assessment issues in their classrooms (e.g., Collis & Romberg, 1991).

This paper provides an overview of the reactions of teachers to applying SOLO as a framework to underpin new assessment practices in their classrooms. The overarching aim of the project described in the paper 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. The initial focus of the program was, however, assessment based, with each teacher establishing the language, understanding and skills necessary to apply SOLO within their classes.

The Project

The project was developed to trial and evaluate teachers' applications of a theoretical framework in the classroom as a means of improving their assessment practices. Specifically, an initial research question for the project was:

> What observations do teachers make about their changes to assessment and teaching strategies as a result of a one-year sustained professional development activity that focuses on using the SOLO Model as a theoretical underpinning to qualitative assessment practices?

This focus arose directly from the changing assessment practices necessary to satisfy the requirements of new syllabus documents introduced into NSW for mathematics and science subjects. Funding for the professional development program was provided by the Federal Government through its Australian Quality Teacher Project (QTP), while the research component was funded by an ARC Discovery Project Grant.

Participants

Twenty-one teachers, representing six schools, volunteered to be included in the project (see Table 1). Four schools were secondary and with three being drawn from rural areas and one from coastal NSW. The two primary schools were from rural NSW. Within each school, there were at least two teachers working in the same area (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.

Table 1
Participatory Sample in Subject Discipline or Year Level (n=21)

Secondary Teachers	Mathematics	Science
School 1	2	3
School 2	2	2
School 3	2	2
School 4	2	2
Primary Teachers	Kindergarten Years 2, 3 & 4	Years 5 & 6
School 5		2
School 6	1	1

Design

Initially, a two-day workshop was conducted. This was held at the University thereby enabling participants to be removed from their normal work environment. In addition to this workshop, two other workshops were conducted at the University in June and November, and teachers were visited by members of the University project team in their own teaching context throughout the year. Funding for the project provided release time for teachers to be covered during their absence from their school, and for opportunities for teachers to have some time to devote to the project during normal working hours, including University team visits.

The first year of the program was designed to enable 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 first workshop, teachers were given the opportunity to provide 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, asked for a series of two-hour after-school sessions. These needs were clarified and refocused as the teachers became more familiar with the program and SOLO. Similarly, teachers were able to select the best course of action for the August-to-September period by negotiating with the project team. In this manner, teachers were given a high degree of ownership in terms of the direction of the project, session input and individual group focus.

At the final workshop meeting in November, all participants along with the project team decided on an individual school plan for the following year. This action was deemed

to be the best way of ensuring that the particular needs of teachers in specific schools were met. As a consequence, each of the four secondary schools developed a distinct program for the second year under the direction of the project team.

In addition to the flexibility of the design, ongoing consultative help was available for the teachers between workshop sessions. 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 to have the project sensitive to, and reflective of, the wishes and needs of the participants. Within the constraints of the budget, every effort was made to respond to an individual school's request for support. This included money for teaching relief, more information and advice through 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 University team.

Data Gathering and Analysis Techniques

Within the initial phase of the research, reported in this paper, are two primary sources of data collection. These were: (i) teacher perspectives as to how the utilisation of the SOLO model affected their assessment and teaching practices in the classroom, and (ii) student scripts coded using the SOLO model to inform knowledge acquisition within content areas. This paper reports on the data collected from mathematics teachers and their perceptions of the way in which their assessment and teaching practices were influenced by participation in the project.

Data were gathered during each of the workshops and on school visits. This occurred during initial sessions at these meetings in which teachers were asked to comment on the ways in which the analysis of assessment items using the SOLO model was influencing their classroom practices. Each of the interview sessions was taped and later transcribed. This had the approval of all participants. In addition to this, teachers were interviewed at the end of the year. All interviews were transcribed for analysis. NUD*IST was used to assist in the analysis of the teacher interviews.

Results and Discussion

The results discussed in this paper are considered in two sections. The first provides some of the ways in which teachers felt they had changed their assessment practices in the classroom. The second outlines some of the reflections made by teachers in relation to their teaching strategies. In response to ethics requirements and concern for the confidentiality of teachers, references to, or implications concerning, the name, school or gender of each teacher have been removed.

Changes Identified in Relation to Assessment Practices

One of the most frequent comments made by teachers in the initial stages of the project was recognition of the importance of the kinds of questions used to gauge student understanding in their classrooms. As time went on throughout the first year, they became aware of how limiting many of their questions were in providing insight into the degree of understanding held by students.

Rarely, teachers reported, did they give their students the opportunity to engage in extended-response items. For example, Teacher A stated during an interview that as a result of the program "My tests have changed quite significantly and I am now conscious

of including questions, and wording them more appropriately, to enable students to reach relational (higher-level) solutions." The main reason for this change was the realisation by the teachers that understanding could be gauged more effectively from these types of responses rather than on how well students performed on algorithmic driven questions. The teacher went on to comment "in the past I would have always asked a question like 'Graph this region on the number plane' and never realised that I was asking a multistructural (procedural) type question."

The teachers also felt more confident in being able to determine differences or degrees of understanding in the extended-response items having participated in the workshop sessions. Teacher B "Trialled some (extended-response questions) in a Year 8 exam and some of the teachers commented on the 'different style' and were concerned that their students may not cope well. Bright students did not necessarily give the highest responses."

Picking up on this point, Teacher C reported that in a "question on simultaneous equations, students in two same-level classes were asked to 'explain their answer.' Students in the class where this type of activity was never done before hated the question. These students were only ever asked to find an answer and that maths was 'black and white' for them. Students in the class where explanations were encouraged did not complain – they enjoyed it!" As a consequence of this type of action, Teacher D said "I now teach more 'processes' than straight recall. I try to guide students in their thinking."

The implications for those involved in more qualitative assessment practices was encapsulated by Teacher E. "I realise that there is another way to assess students ability and I need to provide opportunities for students to demonstrate what they have learned in each topic. To do this, I need to reassess 26 plus years of custom and practice and to provide my colleagues with a solid 'theoretical' basis to change their ideas also."

Similarly, Teacher C stated "I now have a better grasp of the difficulties students have with their work and why they find these things so hard." This particular teacher had expressed some of the frustrations identified in working with students and wanting to help but not sure why they were struggling with particular concepts. Although Teacher C had done some work with models of learning, the study had been undertaken many years ago and was a distant memory. For this teacher, working with other colleagues and utilisation of a theoretical framework provided an opportunity to become re-acquainted with ways in which to enhance pedagogy so as to improve student learning.

While the comments made by teachers thus far focus on the applications to the classroom, many of the teachers considered that the utilisation of a theoretical framework for assessment helped them to justify the judgements being made about assessment. "I think SOLO has made me harder on myself. I sometimes look at tasks I designed a while ago before I did the course and I could kick myself on what I did. I can see I placed ceilings on questions a lot of the time. And also I would think the students were doing really well, but it's only because of the limited nature of the questions I asked. Other times I had thought I had been asking a question on a certain thing, but in reality it had been a question that had targeted something completely different. SOLO has made me a lot more focused on what I aim to assess and to do it in a better way" (Teacher F).

Each of the comments from teachers discussed above demonstrates different ways in which teachers were able to use the model to help them in assessing, usually formatively, what their students understood. Of interest is that teachers were quite tentative at the beginning of the project to develop their own questions. They were apprehensive that the questions would not generate a variety or 'degree of understanding.' To offset this,

teachers were given help with potential items. However, by the end of the first year, teachers were modifying old test items and questions from other sources to use with their students and analyse using SOLO. While the emphasis in this discussion has been mainly on written responses, many of the teachers became comfortable enough to start analysing the verbal responses provided by the students during lessons.

Changes Identified in Regard to Teaching Strategies

In addition to the changes described above, teachers recognised that they were making major changes in regard to teaching strategies and practices. The most frequent comment was in relation to the types of questions being used both during classroom dialogue and in assessment tasks. For example, Teacher H stated "I am more conscious of allowing and assisting students to develop the pathways necessary to higher-level thinking. I have tried to avoid 'dumbing down' but have found with low ability classes that they get annoyed with me and just want to know 'how to do it.' I suspect this is partly because previous teachers have 'dumbed down' and students see it as 'good teaching.' It was the exposure to this theory that has really catalysed my thoughts in this area."

As one example, Teacher F noted "One teacher came to me the other day and said 'Look, I've got this really good method of doing significant figures.' I looked at it, and it was a foolscap page of four different rules. It started at the top and went to the bottom." Teacher F went on to say that this teacher was only offering the class a set of procedures that they had to learn and follow, and that prior to working with SOLO Teacher F would probably have thought that such an approach was justified and appropriate.

The teachers in the study found also that they were giving students greater opportunity to 'talk' in their classes. "I talk more often with my classes about what they are thinking and I make more effort to keep linking topics, hopefully helping students to work towards higher-level thinking" said Teacher G. These efforts were enhanced by teachers changing their style of questioning. Teacher C stated "Students are provided with numerous opportunities to explain in their own words what we are working on at the time and what it means to them. I find it most rewarding and I have a different atmosphere in the classroom." While this notion of questioning is not a new idea, teachers felt that they had a reason for putting more time into their questions in that they could see that it did make a difference for the students. "My questioning style in teaching has improved in order to draw information from students" Teacher A reported.

However, one of the most important ways that the analysis provided by the SOLO model impacted on teachers was by allowing them to 'diagnose' responses. "I now keep a close watch on 'working memory' and I now try and provide something for students to 'hang' new information on" said Teacher H. The teacher went on to list improvements in teaching approaches such as being "Better able to distinguish between student's abilities more clearly, better able to provide more suitable work in accordance with how students think, better able to understand student difficulties in grasping new work, and better able to present material in a more meaningful way."

The comments provided by teachers in the discussion have identified a number of ways in which teaching practices were enhanced by using the SOLO model to analyse students' responses. The following comment from Teacher C was particularly interesting "I now spend 'real' time preparing lessons." This comment emerged during the final workshop for the first-year of the project. The comment was supported by the other teachers. They recognised that working with colleagues and discussing their teaching practices had made each of them aware of the importance of thinking carefully about what students understood

and the ways in which this could be improved. In other words, they felt that lesson planning was crucial and realised that effort really needed to be "put in here if learning is to improve" (Teacher C).

Conclusions

The results described in this paper have provided insights into the experiences of secondary mathematics teachers involved in a project to apply a theoretical model so as to improve assessment practices in their own classrooms. In terms of the content addressed during the course of the first year, participation gave teachers a means for exploring student understanding using a cognitive model and provided a framework upon which to consider their teaching practices so as to build upon these understandings. Teachers became critical of their own practices, realising that questions that only require standard algorithmic procedures can restrict their students to rote learnt approaches. There was also the "realisation that teaching short cuts can lead to level reduction. This, in the long term, reduced how well students functioned. Now I emphasise procedures and when an answer is gained ask, Why?" said Teacher C.

The research question can best be answered by a sentiment expressed by Teacher D who summarised the views of all teachers in the study: "SOLO is the kind of thing that once you know it and you understand what's going on with it, it is very hard to ignore what SOLO is telling you to do. And you start to view what the students do lesson by lesson in terms of SOLO. It works in a number of ways. If you get to know the developmental pathway that students go through by observing what they are doing, then with new topics you can predict, because you know the structure, and not only when you are planning units and lessons, but also in your everyday questioning. So if your students are performing certain elements that are disjointed, you can make the questioning to edge them towards higher-order responses."

As a consequence of the outcome of their participation, all of the teachers indicated their willingness to be involved in the second year of the project. There are a number of directions to be taken by groups of teachers for 2004 including the:

- ☐ Assessment of research reports using the SOLO Model;
- ☐ Use of pre and post analysis of students' understandings of topics;
- ☐ Identification of links between the standards from the syllabus for HSC and criteria using the SOLO Model; and
- ☐ Development of superitem questions based on particular topics in mathematics and science.

Acknowledgement

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