Enhancing rural teachers’ instructional decision making: An application of the SOLO model

John Pegg (SiMERR, Australia)

ABSTRACT

This paper reports on the underlying theory base and implications for practice of two large-scale research projects carried out in rural and regional schools in Australia by teams of academics associated with the SiMERR National Centre. The research was a collaborative effort with funding provided by the Australian Quality Teacher Project and the Australian Research Council. The two research projects ran for a two-year and three-year period with the Catholic Schools Office in the Diocese of Armidale and the New South Wales Department of Education, respectively. Both projects aimed at empowering groups of teachers in rural areas to develop and use theoretically-based knowledge about assessment to improve teaching in ways that best fit their students’ needs. To achieve this, teachers were required to assess the quality of their students’ learning, and to use the information obtained to inform where teaching might start and in what direction to best proceed. The driving philosophy of the research was that student learning and, consequently, well-being is enhanced when instructional decision making involves teachers understanding what knowledge their students posses, and the nature/quality of that knowledge in order to build upon students’ understanding. This paper (i) describes briefly the background to the projects and rationale; (ii) explores the theoretical framework, referred to as the SOLO model; and (iii) discusses some findings and implications associated with the use of the SOLO model by rural teachers.

I. INTRODUCTION

Schools report numerous ways of addressing student well-being. In Australia,
programs directed at student welfare include those that: provide a sustaining breakfast for students in need; incorporate behaviour management, personal organisation and/or leadership courses into the school day; and offer out-of-school experiences in terms of targeted excursions (Paterson, Graham, & Stevens, 2007). These and similarly focused programs can take a variety of forms depending on the school and community context.

However, student well-being can also be addressed, in part, through students achieving successes in acquiring school subject expertise. In such cases, the instructional techniques that underpin success are (i) a teaching focus incorporating high expectations on individual students and their learning, and (ii) the establishment, over time, of student trust in their teachers (Paterson et al, p.71, 2007). Hence, student well-being is most likely if instruction programs concentrate on establishing both the most appropriate conditions for learning, and the nature of students’ readiness for specific academic development.

These ideas are particularly relevant to students in rural Australia. In Australia, students in rural and regional areas do not achieve as highly as their metropolitan peers in mathematics and science (e.g., Thomson, Cresswell, & De Bortoli, 2004; Thomson & De Bortoli, 2008; Thomson, De Bortoli, Nicholas, Hillman, Buckley, 2011). While there is a growing body of research evidence around issues thought to impact on student under-achievement in rural schools (MCEETYA, 2003; Roberts, 2005; Vinson, 2002; Yarrow, 1998), there are limited data relating explicitly to how this situation might be addressed.

The National Centre of Science, Information and Communication Technology, and Mathematics Education for Rural and Regional (SiMERR) Australia was in a unique position to consider both under-achievement and well-being of students in rural schools. In doing so the focus was twofold. First, to improve the learning outcomes of rural students and, second, to help build associated feelings of well-being in students by supporting teaching staff to better target their instruction (where to start and where to move to next) to the needs of their students.
It is these ideas that underpin the use of the evidenced-based developmental framework, described in this paper, based on assessing the quality of students’ responses to questions. This form of assessment provides the means of interpreting students’ responses within a framework of cognitive developmental growth, thus allowing teachers (and students) to place learners on a developmental continuum and, at the same time, provide advice to the teacher on more appropriate pathways for future teaching endeavours (Biggs, 1996).

### II. Background

The background for the investigations described below can be seen, in its simplest form, within two main educational assessment paradigms – qualitative and quantitative. Assessment techniques described as predominantly quantitative, are usually summative in nature and tend to focus on single marks, facilitating ranking of students. This approach is often referred to as traditional or normative assessment, and dominates much of current practice.

Qualitative assessment, on the other hand, represents a departure from a focus on testing for skills, facts and learnt algorithms or procedures. The qualitative approach is more closely aligned to identifying and interpreting students’ understandings. As a result, the information provided by qualitative assessment techniques usually can be linked directly to the specifics of what is taught, and inform the direction of instruction (Black & Wiliam, 1998; Wilson & Sloane, 2000).

Both perspectives (quantitative and qualitative) have their place, depending on the purposes addressed, and, interestingly, when adopted individually, both approaches have issues. There is little advice in the quantitative form of assessment for the learner or teacher except for the students to “work harder” if the scores are low and “keep up the good work” if the scores are high. Also, there is a reverence associated with such scores (e.g., over 50% is a pass under 50% is a fail), by many in society, of a degree of accuracy from testing that does not mirror reality. For the qualitative approach there is often too much information available, and students, parents and teachers can often be swamped with large checklists and ‘mountains’ of information which are difficult to synthesise.
It is the latter form of qualitative assessment that underscores these two projects and provides a balance to more traditional practice. This qualitative framework is given the name SOLO standing for the Structure of the Observed Learning Outcome (Biggs & Collis, 1982). A significant theme within the research was helping teachers to unpack the assessment for learning agenda as a complement to the more traditional assessment of learning.

1. Professional learning model

The two research studies involved groups of teachers in rural settings over two and three years, respectively. The studies, while different, share the common aim of exploring the impact on, and implications for, immersing practising teachers in an environment where they were supported in learning about and applying a cognitive developmental framework (the SOLO model).

In the first of these projects (see, Panizzon & Pegg, 2007, 2008; Pegg & Panizzon, 2007) primary and secondary teachers were asked to explore the changing emphasis of assessment and how they reconceptualised these changes in practice by working with SOLO as the underpinning theoretical framework.

The second study was titled the Impact of Developmentally-based Qualitative Assessment Practices in English, Mathematics, and Science on School Policies, Classroom Instruction, and Teacher Knowledge (Pegg, Panizzon, Callingham, Baxter, Wright, 2008). Its purpose was to provide school systems, subject departments and teachers, evidence on how different forms of assessment and assessment information can improve the learning environment for and the well-being of students.

Both projects initially required teachers to undertake a two-day professional learning workshop. During this workshop, pre-existing teacher conceptions regarding assessment and teaching practice were investigated as well as notions of well-being in students linked to subject learning. The basics of the SOLO conceptual framework were also introduced. By the end of the first workshop, teachers saw the potential of SOLO as a powerful and realistic means of addressing issues they were confronting. It was stressed that the purpose of the project was to assist and support particular existing professional experience and pedagogical beliefs regarding personal teaching practice, rather than to add new approaches for teachers to acquire. Hence, there
was a strong evolutionary, as opposed to revolutionary, approach to skill development (Pegg, Lynch, & Panizzon, 2007).

In order to enable teachers assess material in their classrooms, help was provided in preparing assessment items, which lent themselves to a SOLO analysis. Discussion also ensued regarding ways in which SOLO could complement rather than replace traditional classroom tests and current school assessment practice. This initial workshop also included sessions for forward planning and identification of teacher needs and support mechanisms available over the following months. Goals were set based on workshop content and learning experiences, and were largely driven by the underlying aims of the project with direction input by the teachers regarding timing of workshops and learning/support needs. Subsequent school-visits and workshops required teachers to carry out tasks that would add to their learning experiences in these workshops <Table 1>.

A minimum of two teachers (including the subject coordinator) attended all workshops. It was their responsibility to share the workshop information and ideas with their peers when they returned to their school. Additional teachers could attend workshops but individual schools met any costs in terms of teacher release, travel and sustenance. Funds were also allocated to allow teachers in a subject area in a school to meet to plan, discuss, and evaluate their progress. Table 1 provides a typical year program involving a series of three two-day workshops as well as support and one on-site visit.

<Table 1> Typical timeline for each year of a project.

<table>
<thead>
<tr>
<th>Month</th>
<th>Instruction type</th>
</tr>
</thead>
<tbody>
<tr>
<td>February</td>
<td>2-day initial workshop at a cost-effective venue</td>
</tr>
<tr>
<td>March to May</td>
<td>Constant access to expertise in order to maintain momentum of the aims of the project and facilitate teacher growth through the concepts covered at the initial 2-day meeting in February</td>
</tr>
<tr>
<td>June</td>
<td>Second 2-day workshop at a cost-effective venue</td>
</tr>
<tr>
<td>August</td>
<td>On site visits to each of the schools and faculty groups involved to discuss concerns, programming, and assessment, particular to each teaching staff.</td>
</tr>
<tr>
<td>September</td>
<td>End of Year 1 workshop at UNE to discuss progress to date and determine a more focussed approach based on participant experiences of the program.</td>
</tr>
</tbody>
</table>

The end of year workshop consisted of each school-faculty group presenting and
sharing their experiences from their involvement in the project thus far. Teachers were free to comment on aspects of these presentations and share relevant findings at appropriate moments within these presentations. From these presentations as well as school-faculty group sessions, project direction for the next year was derived. Additional to these organised meetings, participating teachers had constant access to expertise of the members of the research team via telephone, email and web-based support.

2. Aims and Rationale

The aims of the projects were for teachers to explore, and develop skills associated with assessment techniques that measure the quality of student understandings in mathematics and science across a number of school years but, in doing so, provide a sounder basis for teachers’ instructional practice than currently exists. It was expected that through participation in these projects, teachers would:

A. obtain a balance to more traditional approaches of assessment, which are usually concerned with how much has been learned;
B. be assisted to focus on how well material is understood as opposed to how much is remembered;
C. be introduced to the notion of considering the quality and nature of the learned outcome by exploring the nature of the structure of the students’ understanding; and,
D. take this information about student understanding and use it as a basis to provide an improved learning environment for their students.

III. Introduction to the SOLO model

The Structure of the Observed Learning Outcome (SOLO) (Biggs & Collis, 1982, 1991) model has much in common with the neo-Piagetian frameworks of Case (1992), and Fischer and Knight (1990). SOLO was developed to focus on the structure of students’ responses after a learning experience. Underpinning the model is the assumption that cognitive understanding does not equate to a stable cognitive
Sensorimotor

(soon after birth)

This mode becomes available at birth. It encompasses the coordination of actions and the learning of motor skills within the physical environment. As this type of knowledge involves ‘knowing how’ to complete a physical task, it is termed tacit knowledge. This mode plays a role throughout life particularly in relation to sporting or other physical skills.

Ikonic

(from two years)

Accessibility to this mode occurs as actions become internalised by the individual resulting in the use and development of language and imagery. Young children in this mode use stories and mythical
characters to explain human interactions while adults use the mode to assist in appreciating music and art. Thinking intuitively is a good example of adults working within the ikonic mode. Working in this mode involves a major shift in abstraction as concepts and operations are applied through the symbolic systems of written language, number, and musical notation. These systems involve an internal logic and order or ‘knowing what’ as individuals describe their experienced world using symbolic descriptions. It is this mode that is addressed most commonly with learning in the upper primary and secondary school. Within this mode, individuals seek to understand the relationships between concepts as their thought processes become more abstract and they move away from the need for concrete referents. They are able to question ideas and formulate hypotheses within specific disciplines. This is considered as the highest level of abstraction required in professional practice and at an undergraduate level.

This mode is demonstrated in postgraduate study where the conventional principles of a discipline are questioned and explored further so that the knowledge of the discipline expands. There is some debate, however, about the existence of this mode.

While the five modes of thinking are distinct and become available in the order provided above, the functioning in a later acquired mode (e.g., concrete symbolic) does not preclude the use of an earlier acquired mode (such as ikonic or sensorimotor) to support understanding. This is referred to as multi-modal functioning. The important consideration here is that all modes are available and continue to develop throughout life in response to experiential, social, cultural, educational, or genetic factors (Collis, Jones, Sprod, Watson, & Fraser, 1998; Pegg, 2003).

It is important to note that there is no implication here that a student who is able to respond in the concrete symbolic mode in one context is able or would wish to respond in the same mode in other contexts or in the same context at different times. Nevertheless, this list implies that most students in elementary and secondary school are capable of operating within the concrete symbolic mode, usually the target mode for instruction in primary and secondary school, and teaching techniques should be adapted to suit learners at this mode. Some students may, however, still respond to stimuli in the ikonic mode, while others may respond with formal...
reasoning in some topics. Paramount is that each mode has its own identity, its own specific idiosyncratic character, and the potential for continuing development over the life of an individual.

2. SOLO levels

The second characteristic of the model is a series of levels that measures an increasing sophistication in handling certain tasks within a particular mode. In terms of the second feature of the model, three levels of responses make up a cycle of learning within a mode. These are:

- **Unistructural (U)**: Indicates that the individual has understood the task but can relate only one piece of relevant information. While the content of the response may be consistent with the data, inconsistencies often emerge within the response itself.

- **Multistructural (M)**: Occurs when the individual is able to identify two or more pieces of data relevant to the question but there is a lack of integration.

- **Relational (R)**: Demonstrates that the learner is able to identify a number of elements that are consistent with the question and relate them to one another around a particular concept. However, this level of response does not take general principles into account so that generalisations are not consistent within different contexts.

The modes of thinking and levels of responses within these modes are summarised in [Figure 1].
3. Paths of development

Also included on the diagram in Figure 1 are four arrows (named Course of Optimal Development, Uni-modal development, Lower Order Learning, and Higher Order Learning). These refer to important paths of development within the model, highlighting different aspects of intelligent behaviour (Biggs & Collis, 1991). While the modes represent the level of abstraction at which individuals of a particular age may function, in many instances individuals operate in earlier-acquired modes, use a single target mode or use a number of modes within a learning context. The following discussion considers the learning and teaching implications associated with each of the arrows in turn.

Course of Optimal Development assumed by stage theorists, such as Piaget, occurs where an emerging stage replaces its predecessor. The SOLO model does not support this view but considers that learning in earlier acquired modes supports the development of higher modes. This allows us to access all the acquired modes throughout our lifetime.

Uni-modal development represents the most straight-forward case of learning. The
problem for a teacher is that by addressing learning from purely a concrete symbolic approach, ignoring ikonic and sensori motor, the subject matter can become decontextualised and removed from the development of the student.

In contrast, Lower Order Learning and Higher Order Learning represent multimodal learning, which is considered to be the most relevant to classroom teachers. In these cases there is a target mode but teachers evoke and address in their instruction other acquired modes in support.

Higher Order Learning is termed top-down learning as it identifies those instances when an individual uses higher-order modes to improve their performance in an earlier acquired mode. This is demonstrated when athletes working predominantly in the sensori motor mode, watch videos (ikonic mode), or read books (concrete symbolic mode) to improve their performance.

Alternatively, Lower Order Learning is referred to as bottom-up learning as earlier acquired modes are used to support learning in a higher target mode. This approach is common in classrooms, for example, in science classes when students undertake investigations (involving lots of sensori motor activity), view and talk about demonstrations (illustrating the ikonic mode), come to use and explain phenomenon using science language and ideas (concrete symbolic mode) to facilitate their understanding of an abstract concept or principle within the formal mode.

4. Two cycles of levels within a mode

Research into SOLO levels in the 1990s (e.g., Campbell, Watson, & Collis, 1992; Pegg, 1992; Pegg & Davey, 1998) identified an earlier cycle of levels present within the concrete symbolic mode than had previously been discussed. This finding arose when students’ responses were analysed over a greater range of learning situations than had been undertaken in earlier research. Significantly, a single learning cycle (i.e., U-M-R) was not seen as sufficient to explain fully the development of concepts or the diversity evident in responses within a mode. Subsequently, an additional learning mode. This earlier cycle represented an interface between responses in the ikonic mode and those traditionally categorised as concrete symbolic. Consequently, the responses in this first cycle were characterised by strong visual elements combining over the three levels to give a focus on a single idea or concept. The two
cycles in the concrete symbolic mode is indicated diagrammatically in [Figure 2].

[Figure 2] A diagrammatic interpretation of two cycles within the concrete symbolic mode

In both the first and second cycle in the concrete symbolic mode, the nature of the response, i.e., the degree of abstractness, remains the same. For example, in the concrete symbolic mode the first cycle U1M1R1 and the second cycle U2M2R2 are both distinguished from cycles in the formal mode by their dependence on empirical cues, development being marked by a lessening of dependence upon empirical support as responses move from U1 to R2. Reality for the child in the concrete symbolic mode is seen as being bound up with the notion of closure and uniqueness which is related to both the nature of elements operated upon, and the number and type of operations involved.

IV. Findings and Implications

In the first project, SOLO was linked to identified changes in teacher’s practice in: types and varieties of questions used; references to cognition in explaining the development of higher-order skills; framing teacher thoughts about their pedagogical
practices; influencing techniques used in the classroom; identifying current student understanding so as to more explicitly drive the focus of lessons; developing positive changes in classroom interactions among students; and creating positive changes in classroom interactions between teachers and students. Using a grounded theory approach, questioning in the classroom was identified as the core component that became a major focus for all teachers, especially in the first year.

The main finding of the study was that teachers reported a fundamental shift in their perception of learning and this was reflected in their teaching and assessment practices; their colleagues and students noticed and reported changes in their classroom practices and procedures. Understanding and applying the SOLO model was seen as both a catalyst for action and a framework to guide teacher's thinking.

The second project outcomes include details on how to utilise qualitative and quantitative assessment practices, and detailed longitudinal analyses of teacher growth and perceptions as a result of using the SOLO model within the social context of classrooms.

Emerging from this work and to be reported in (Pegg, Panizzon, Callingham, Baxter, & Wright, under preparation) is the observation that while the lower levels of UMR can be taught in the traditional sense, the shift to a relational level response requires a quality in the thinking of the learner, and this cannot be guaranteed by teaching alone. Expanding on this point. There appears to be certain teaching approaches that might be better utilised when students are identified as responding at one level than when at another. Knowledge of this pattern can better help teachers develop a rationale for their actions and help inform the nature of their instruction at that time.

In the remainder of this paper the idea that different SOLO levels might suggest different teaching approaches is explored in more detail.

Let us first consider the case of students who, during an activity, respond at the unistructural level. The implication here is that students provide a single relevant feature/aspect as an answer. In terms of cognitive capacity, the students' role is first to separate the cue (question) and the response. In doing this, students need to hold the question in their mind while answering the question and then be able to relate the question and answer with one relevant aspect. The teaching implications for these students include numerous experiences (to practise) in coming to understand
and be skilful in the use of this single feature/aspect. As this approach proceeds, the single idea takes up less cognitive capacity and this allows the student cognitive space to respond to a stimuli by including more relevant aspects - a situation that would be coded at the multistructural level.

With responses at the multistructural level, students must again separate the question (cue) and the response, but the cognitive capacity of the student now allows for additional aspects/concepts/features to be reported in a serial fashion. The key feature here is that the individual aspects are seen as independent of one another. Here, further practice of the individual elements needs to be pursued as well as activities that draw on the use of many elements. Formal language of the discipline has an important focus here as while practising single-focus questions developed appropriate language, students are now better placed to begin to talk more openly about a variety of elements.

In both the cases (students at unistructural and multistructural levels), explicit teaching had an important place in the process in helping the student to identify the critical aspects of the work being undertaken and to reduce cognitive demand. Such teaching is able to encourage students to see the benefits of a multistructural response over a unistructural one in their improvement in consistency and in undertaking more advanced tasks. However, the key importance on the multistructural level response is the accumulation of numbers of relevant elements by the student.

In facilitating a relational response students are expected to interrelate the elements identified as isolated aspects at the multistructural level. The characteristics of a relational response include students seeing connections among the elements, and an overriding rule or pattern among the data that are identified. Of course students responding at this level are limited by inductive processes associated with moving from unistructural to multistructural and are not in a position to move beyond this context. This movement will occur as they access a new unistructural level in the next cycle.

For teachers who wish to move their students from the multistructural level to relational, the emphasis must move beyond a focus on explicit teaching to one of creating an environment in which students can find their own way, and develop their own connections. The result in teachers explicitly teaching connections at the
relational level has two problems. First the number of connections (implicit and explicit) among the multistructural elements can be very large and hence it can become impossible to cover them all. Second, an emphasis on teaching the relationships among the elements can easily become a new multistructural element and hence not serve the integrative function a particular relationship among elements can achieve.

In overview, the SOLO model is relevant to the classroom for teachers because it provides a framework to describe the underlying structure of understanding demonstrated in students’ responses. By utilising this framework, teachers are potentially in a position: (i) to better target their teaching strategies to the ‘level’ of the students; and (ii) to critically analyse their teaching and assessment practices from a developmental perspective.

V. Conclusion

The strength of the SOLO model is the linking of the hierarchical nature of cognitive development through the modes and the cyclical nature of learning through the levels. Each level provides building blocks for the next higher level.

The discussion in this paper highlights many advantages of applying SOLO. Most obviously, it provides teachers with a common and shared language that enables them to describe in a meaningful way their observations of student performance. However, as a result of these two projects it can be seen that the SOLO framework can provide teachers with greater insights into their thinking about teaching and their teaching approaches. It also adds to feelings of trust and understanding in students of the real basis for assessment and the role their teachers are playing in supporting their development. Although not part of this paper, students’ views on the new approaches adopted by teachers were considerably stronger in those schools were teachers explained the SOLO model to their students and explicitly used it as part of their assessment feedback.

Over time, the application of SOLO by teachers to assess student responses, led most to articulate numerous changes in their teaching practice. Interestingly, these changes were often first noticed and commented on by colleagues in the same
faculty. SOLO was seen as a catalyst for teachers to explore and develop further their practice, resulting in richer learning environments for and greater involvement by their students.

Acknowledgement:

I thank the following colleagues, who were members of the research teams, for their many contributions to the research and ideas reported in this paper. They are: Debra Panizzon, Michaela Inglis, David Baxter, Rosemary Callingham, and Terri Wright. I also acknowledge the financial support and encouragement of the Australian Research Council, the Australian Quality Teacher Project, the Catholic Schools Office in the Diocese of Armidale and the NSW Department of Education.
REFERENCES

Pegg, J. (1992). Assessing students'understanding at the primary and secondary level


