Assessing For Deeper Understanding in Tertiary Examinations in Physical Education Using A SOLO Taxonomy

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This paper describes a project at the Australian College of Physical Education which takes up Boulton-Lewis’ challenge to tertiary educators to implement the SOLO Taxonomy (Structure of the Observed Learning Outcome) (Biggs and Collis, 1982) in order to ‘challenge students to engage in deep learning and to organise and present their knowledge in their own way to demonstrate understanding’ (in Dart & Boulton-Lewis (eds), 1998, p 217) in assessing a specific aspect of Physical Education pedagogy, namely the theory and application of teaching games. A set of examination questions structured to reflect SOLO levels were devised to test relational, higher-order understanding of two approaches to teaching games, Teaching Games for Understanding (TGfU) and Sport Education (SE), the implications of each approach in terms of actual practice and the relationship between these two approaches. Student results indicated that the majority had engaged with both approaches but the SOLO levels described effectively the different levels of understanding and provided an effective discriminating framework for the allocation of grades. This project supports Boulton-Lewis’ contention that SOLO provides an ideal tool for assessing deep learning in the area of Physical Education and provides important feedback and understanding concerning the future teaching and learning of related content at a tertiary level.

Introduction

Changes in Australian syllabuses and pedagogy have had many implications for the practising Physical Education (PE) teacher. The Teaching Games for Understanding (TGfU) approach developed by Bunker and Thorpe (1982) and Sport Education (SE) developed by Siedentop (1994) place a different focus on the teaching of physical education to traditional, technically driven approaches to instruction. These two curriculum instruction models have been developed to focus specifically on game play and to help students participate in fair and equitable competition whilst challenging their thinking about mere replication of game skill/technique. Previous research however shows that pre-service teachers struggle to comprehend and execute TGfU (Randall, 2003) and SE (Curtner-Smith & Sofo, 2004).

Objectives and Significance: Addressing the Challenges of Teaching TGfU and SE in Higher Education

A second-year undergraduate unit, ‘Theory and Application of Teaching Games’, in the Bachelor of Education (Health and Physical Education) is taught at the Australian College of Physical Education in New South Wales. To address the concerns expressed in the research cited above, this unit in 2007 focused on methods of modifying games and activities that enhance ability and awareness in skills, tactics and playing principles through problem-based learning.

The unit was taught using a 1-hour lecture and 2-hour practicum format over a 13-week teaching semester and entailed three pieces of assessment. Lectures were based around the extensive links to the NSW Board of Studies K-6 & 7-10 PDHPE Syllabi. Practicum sessions were TGfU focused and derived largely from the lecturer’s experience and knowledge of TGfU application. Submitted assignments were focused on the deep knowledge required to implement TGfU and SE into classroom practice. Students were required to research obscure sports and demonstrate an in-depth knowledge of the sports culture, history, development, curricular links, and most importantly, how to instruct using the TGfU and SE principles within a school environment to years 7-10. The challenge of developing deep learning, as opposed to surface learning, by constructing game related problems and utilising questioning techniques was a major focus.

Marton and Säljö (1976) completed the original work related to deep and surface approaches to learning. Students typically adopt two differing approaches to learning a new task. The first
approach involved an attempt to remember the facts and details of a new concept and a focus on what students thought they would be asked later. This group demonstrated rote learning, or a superficial, surface approach to the task. A surface approach involves minimum engagement, typically a focus on memorization or applying procedures that do not involve reflection, and usually an intention to gain a passing grade.

The second approach was to try to understand the big ideas; student focus was on comprehending and understanding concepts attached to a specific task. This approach may be considered as adopting a deep approach to learning. A deep approach to learning involves an intention to understand and impose meaning (Marton & Säljö, 1976). Here, the student focuses on relationships between various aspects of the content, formulates hypotheses or beliefs about the structure of the problem or concept, and develops an intrinsic interest in learning and understanding. High-quality learning outcomes are associated with deep approaches whereas low-quality outcomes are associated with surface approaches (Biggs, 1987).

The unit used TGfU and SE models to enhance problem solving and student learning. It also sought to incorporate less traditional sports within these models to provide students with opportunities for problem solving activities in an unfamiliar context i.e. Sepak Takraw, Bocce, American Flag Football, Floorball, Korfball, Lacrosse and Australian Rules Football.

Bunker and Thorpe’s (1982) TGfU model arose from identifying the alarming concentration of technique instruction at the expense of tactical and strategic game understanding. One of the ways TGfU sets out to achieve this purpose is through the use of a Games Classification System (Bunker & Thorpe, 1982) whereby games are taught according to their similarities of tactical and strategic objectives rather than as a sport in isolation. The Games Classifications include Target, Net/Wall, Striking/Fielding, and Invasion/Territorial games. Using a TGfU approach does not neglect skill instruction or acquisition but rather develops these aspects of performance after the generic games’ strategies and tactics are understood.

The second curriculum model, Sport Education (SE) makes an attempt to provide authentic sporting experiences for students (Siedentop, 1994), by developing literate, competent, and enthusiastic sportspeople. It is based on the idea that PE curriculum can be taught with maximum engagement for students by replicating the authenticity of sporting culture, including structured competition. Siedentop (1994) refers to a competent sportsperson as having sufficiently developed skills and understands the execution of appropriate strategy as to participate as a knowledgeable games player. A literate sportsperson understands and values the rules, rituals, and traditions of sports and is proactive in their preservation. An enthusiastic sportsperson participates in sport as part of a physically active lifestyle and acts in ways that serve to protect, preserve, and enhance the sporting culture as to make the sport more accessible. SE programs have several distinct characteristics, which include Seasons, Team Affiliation, Formal Competition, Record Keeping, Festivity, and Culminating Events (Siedentop, 1994).

These two curriculum instructions models share several conceptual similarities. Both models share foundations in Play Theory, emphasis on healthy and competitive game play, authentic learning experiences that conform to contemporary theoretical and instructional designs (Collier, 2005). They also seek to use developmentally appropriate learning activities, indirect teaching styles and small group learning shifting the learning responsibility to students (Hastie & Curtner-Smith, 2006).

Whilst these two models do share considerable similarities in terms of pedagogy, it would be remiss not to discuss the two noteworthy differences identified by Hastie and Curtner-Smith (2006). First, SE has an outward-focus on helping to forge ‘more worthy and humane culture’ (Siedentop, 2002, p.411) as such, transforming the sporting culture for the better. TGfU has an inward focus on player competency and satisfaction, therefore, working within the existing sporting culture. Secondly, SE
has derived its pedagogy from examining quality sporting culture and the administrative/managerial qualities recommended by teacher effectiveness research. Conversely, TGfU’s pedagogy has been driven by students wishing to ‘play the game’ and pressure to produce more successful elite players.

The next evolution of research in TGfU and SE led to investigating the marrying of the two models into a ‘hybrid’ curriculum model (Almond, 1997; Curtner-Smith, 2004; Hastie & Curtner-Smith, 2006). The use of a TGfU-SE Hybrid is still relatively a new approach to teaching PE. Recent research has identified numerous challenges and opportunities in attempting to develop this TGfU-SE hybrid model. These include preserving the integrity of both models, availing enough time to complete unit outcomes and subject matter mastery (Collier, 2005; Hastie & Curtner-Smith, 2006). Probably the most challenging aspect in developing a TGfU-SE Hybrid is negotiating TGfU’s games classification with SE’s authentic sport foundations, since the sport itself is at the heart of literate and enthusiastic participation. Whilst the researchers have some ideas about how these challenges would be negotiated, they were never communicated to the pre-service teachers being examined. According to Hastie and Curtner-Smith (2006), the integration of TGfU and SE has great potential to increase the success of students in physical education although this requires the teacher to have superior content and pedagogical content knowledge. Students are capable of understanding and appreciating the execution a variety of rudimentary skills, complex strategies and tactics, and overarching principles of rules. Finally, students were able to transfer this knowledge from one game to another and develop high order problem solving and motivation strategies (Hastie & Curtner-Smith, 2006). Students were simply given a 1-hour lecture in the final week of semester on the similarities and differences between the two models. They were also given a list of references where they might be able to read more on attempts to integrate TGfU and SE.

Theory: The SOLO Taxonomy and Higher Education
The SOLO Taxonomy (Biggs & Collis, 1982) was chosen to assess student understanding of these sophisticated theories and pedagogies of PE. It is based on Piagetian descriptions of cognitive development and was discovered by observing the developmental pattern of student responses in relation to the concepts of a wide variety of school subjects and has since been extended to tertiary and occupational areas (Hattie & Brown, 2004 p. 4-5). Its strength is its capacity to measure and categorise different levels of conceptual understanding (Chan, Tsui & Chan, 2002; Hattie & Brown 2004; Boulton-Lewis, 1998) and it is particularly applicable to open-ended tasks (Smith & Colby, 2007). In its original form, Biggs and Collis described 5 SOLO levels: Prestructural (students cannot engage with the concept); Unistructural (students engage with one element of the concept); Multistructural (students engage with a number of elements of the concept but cannot see the pattern of relationships between them); Relational (students identify the links between the elements of the concept); Extended Abstract (students engage with a number of elements of the concept but cannot see the pattern of relationships between them). Relational and Extended Abstract responses have been linked to the conception of deep learning, while Unistructural and Multistructural responses reflect surface approaches (Ramsden, 2003, p.57) Subsequent research has largely maintained this formulation but extended it in attempting to do justice to the observed variety and complexity of student responses. Chan, Tsui and Chan (2002), for instance, developed sub levels within each SOLO level (such as Multistructural low, medium and high) in their studies of long essay responses at tertiary level in order to address what they saw as its ‘conceptual ambiguity’ which made ‘categorisation unstable along with the problem of low inter-rater reliability’ (Chan, Tsui & Chan, 2002, p.512). John Pegg’s research (2003), on the other hand, has resulted in a different approach, again based on large numbers of student responses especially in secondary Mathematics and Science.

Pegg has identified two cycles of responses within the Concrete-Symbolic and Formal modes rather than one (Pegg, 2003; Panizzon & Pegg, 1997). Pegg's research identified a pattern in responses to open-ended questions about subject-related concepts that students' responses in the Concrete-Symbolic mode characteristically exhibited a first cycle of Unistructural, Multistructural and
Relational levels (U1, M1, R1) in which their engagement with the topic tended to be at a fundamental layman's level relying on their own 'common-sense' language rather than the metalanguage of the subject or that associated with the particular topic. This was followed by a second cycle of Unistructural, Multistructural and Relational levels (U2, M2, R2) in which students entered the subject world and were able to explain its concepts in terms of its metalanguage and ways of categorising knowledge. In the first cycle students tend to construct a story or narrative about the concept or topic thus reducing it to their own familiar worlds, but in the second cycle students become comfortable with concept metalanguage, can use it appropriately, perceive cause-and-effect relationships between the elements of the concept and tend to construct arguments in which those sorts of relationships are explained in varying amounts of detail. Another way of putting this is to say that in first cycle responses it is as if students see their task as describing a phenomenon while in second cycle the task becomes less focused on the surface, factual features of the phenomenon but rather on explaining its internal workings and applying it in contexts conventionally associated with its use in a particular subject. Students who were able to relate these concepts to larger patterns of abstraction, enter into critical evaluation and deconstruction or apply the concept in new ways, outside the conventional field associated with these concepts, were operating in the Formal Mode, which was itself also characterised by two SOLO cycles (Pegg 2003, p.245). Pegg has therefore tended to see the sort of thinking represented by Biggs and Collis as ‘extended abstract’ as the defining feature of the Formal Mode and itself subject to the same cyclical development as occurs in the Concrete Symbolic.

This research focused on Pegg’s two-cycle approach (Pegg, 2003), see Figure 1, largely because it seemed to provide a more structured account of the intellectual journey students go through in learning new concepts. As experienced teachers, we recognised the cycles and the levels in the variety of groups of student responses we had seen over a number of years in both secondary and tertiary settings. We were also interested in the potential of applying the two-cycle approach to the traditional tertiary grading system of High Distinction to Fail. The unit ‘Theory and Applications of Teaching Games’ seemed to offer an ideal opportunity to work with SOLO because the concepts involved in the unit themselves represented Formal mode responses to the central pedagogical problem of how to make PE engaging for students and not just a catalogue of decontextualised micro-skills or a succession of games. The unit aimed for more than just surface comprehension of the features of each approach to teaching PE but for deep learning associated with an understanding of the philosophy behind each approach, an ability to apply that philosophy to pedagogical contexts and a capacity to compare the approaches concerned.

![Figure 1: Two-cycle SOLO Model (Pegg, 2003)](image)
TGfU and SE represent sophisticated philosophical, pedagogical and conceptual responses to PE. In developing understandings of these approaches undergraduate students had to negotiate worlds containing the surface features that make up the distinctiveness of each approach (which we saw as first cycle), the internal and philosophical relationships between these features (which we saw as second cycle) and the applications within the discipline to which these features are conventionally put (second cycle, with some access to the formal mode). The ability to critically evaluate the approaches and their applications represents a further stage of cognitive development, associated by Pegg with the Formal mode. In setting the examination for the unit dealing with TGfU and SE, we deliberately aimed to create opportunities for students to respond at all levels; that is, to create open-ended questions which would not restrict responses to any single SOLO level or cycle, but which would allow students fully to display their understanding and capacity to make judgements while still rewarding accurate factual and procedural knowledge.

**Design – The Examination Questions and SOLO Levels**

The final examination and focus of this study was a 3-hour written examination consisting of 3 sections. Section 1 addressed student understanding and asked students to justify the appropriateness of TGfU as a teaching model. Section 2 addressed student understanding and asked students to justify the appropriateness of SE as a teaching model. Finally, section 3 addressed the student’s ability to consider and argue whether an integrated version of the two models is possible.

Before setting the examination, the researchers consulted John Pegg at the University of New England concerning the applicability of SOLO to our chosen content, the best ways to elicit deep understanding of the concepts in setting questions and the likely nature of student responses in two cycles. He advised us that we could expect to see SOLO cycles at all levels of knowledge of the concepts from the mastery of basic terminology, such as that involved in the Game Classification system of TGfU, to the ability to explain the philosophy behind each concept, to the capacity to apply the concepts in familiar and unfamiliar contexts and finally to critical evaluation and comparison between the concepts. (See Table 1 for the actual questions set and the SOLO levels associated with them).

Accordingly, we designed questions that allowed for a variety of levels of response reflecting the quality and depth of conceptual understanding as can be seen in Table 1 below.

Table 1: *Structure of examination*

<table>
<thead>
<tr>
<th>Examination Question</th>
<th>Highest SOLO Level Aimed For</th>
</tr>
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<tbody>
<tr>
<td><strong>Section 1</strong></td>
<td></td>
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<tr>
<td>You are being interviewed for a position as a PDHPE teacher at a school that is about to organise its Stages 4 and 5 curriculum on the principles of Game Sense/Teaching Games for Understanding (TGfU)</td>
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<tr>
<td>Q1 (a). Describe the Games Classification System. Ensure you include examples of games that fall into each category.</td>
<td>Multistructural</td>
</tr>
<tr>
<td>Q1 (b). In as much detail as possible, explain the pedagogical principles associated with teaching this model.</td>
<td>Relational</td>
</tr>
<tr>
<td>Q2. State your understanding of the TGfU model, in as much detail as possible. Why does it provide a sound basis for teaching physical education?</td>
<td>Relational</td>
</tr>
<tr>
<td><strong>Section 2</strong></td>
<td></td>
</tr>
<tr>
<td>Australian Council of Health, Physical Education, and Recreation (ACHPER) has called for its membership to make comment on Sport Education and its implementation in NSW High Schools. Write a letter to your state branch</td>
<td></td>
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</tbody>
</table>
addressing:

| Q3. The characteristics of the Sport Education approach | Multistructural |
| Q4. Your understanding of Sport Education pedagogy, in as much detail as possible, and why it provides a sound basis for teaching physical education. | Relational |

**Section 3**

You are attending a conference hosted by the NSW PDHPE Teachers Association. You have been asked to participate in a debate whereby you must argue the affirmative or negative to the following question:

| Q5. That it is possible to effectively integrate TGfU and Sport Education concurrently into teaching practice or are they completely incompatible? | Relational/Formal |

Further considerations in setting the examination were firstly to provide opportunities for student working memory to be activated at lower levels before proceeding to higher levels. Thus sections 1 (question 1a) and 2 (question 3) began with description or listing questions that focused students on the features of each model without requiring them to integrate those features into an interpretive frame or pattern of argument. As Biggs (2003) has maintained, shaping questions to elicit Relational responses to professional problems is significant because generally in tertiary education students are largely expected to make this transition from surface to deep level knowledge on their own. Activating working memory at the Multistructural level with a lower order question such as ‘Describe the Games Classification System’, provided students with a basis for marshalling information that the subsequent questions of Sections 1 (questions 1b and 2) and 2 (question 4) asked them to shape into Relational responses, thereby giving students a platform for moving to the higher order thinking required. Directions like ‘state your understanding in as much detail as possible’ were given to ensure that students were not restricted in their responses to lower-order thinking, though students at that level could also respond legitimately. This sequencing also applied to the models themselves, which were treated in turn in Sections 1 and 2 before asking students to hypothesise about the possibility of relationships between them in Section 3. Secondly, each section provides a real-world or functioning/professional context (Biggs, 2003; 43), requiring students to adapt their knowledge to a situation requiring persuasion and argument rather than mere description.

**Findings:**

At the simplest level of response, SOLO first cycle in the Concrete Symbolic mode, students simply regurgitated the features of the TGfU model. Unistructural (U1) answers were brief and referred only to one main element of the model, such as Game Classification. Multistructural (M1) responses listed a number of elements, while a Relational answer in the first cycle (R1) discriminated between features, seeing some as more important than others or as their preferred feature or having a sense of the logic with which the features were ordered. In the second cycle, Unistructural (U2) responses began with an overarching interpretive frame, giving their answer the appearance more of an argument than a description, and then proceeded to list elements of the model in terms of how they related to that thesis. Multistructural (M2) responses often listed a number of conceptual advantages of the model within a similar structure, whereas Relational (R2) answers drew relationships between advantages or discriminated between them. Some students related TGfU to larger patterns of abstraction, seeing links with constructivism, for instance, and we felt that in doing so they were moving into the Formal mode. A similar pattern in relation to two SOLO cycles of responses was noted in the Sport Education question, which was similar in format to that for TGfU.
Each section was marked holistically rather than in discreet subsections to ensure that the grade allocated for each section reflected the highest SOLO level of thinking achieved. This meant that each marker read the whole section before determining a SOLO cycle and level based on the reasoning stated above. This allowed the final mark for each section to reflect the highest SOLO level achieved rather than be determined by the aggregation of marks for each separate question. All sections were independently marked by both researchers, with contentious papers reviewed until a consensus was achieved.

Below in Figure 3 is a modified version of Biggs’ model for aligning curriculum objectives, teaching/learning activities and assessment tasks (Biggs, 2003, p. 28). According to Biggs, grades ‘denote a quality of learning and understanding that is the best one that one can reasonably expect for the unit and levels and students in question’ (Biggs, 2003, p. 29). It therefore made sense to allocate traditional university grades for the unit according to the descriptors allocated to each SOLO level. Figure 3 represents how we adapted Biggs’ alignment of curriculum descriptors and grade allocations with the SOLO levels we observed for each question. Student examination responses fell overwhelmingly into these SOLO categories, enabling the allocation of traditional higher education grades, especially in rewarding students exhibiting deep learning outcomes rather than surface outcomes with Distinctions and High Distinction. Using SOLO levels in a two cycle approach enabled us to link the cut-off points for each grade to the level of cognitive thinking and understanding exhibited by students, thus giving an enhanced specificity in justifying grade allocation.

![SOLO levels assigned to grades](image)

Rationale: Examination assesses how well SOLO levels are deployed in context. The highest SOLO level to be observed becomes the final grade

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
<th>Section One</th>
<th>Section Two</th>
<th>Section Three</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Distinction</td>
<td>The very best understanding that could be reasonably expected.</td>
<td>R2</td>
<td>R2</td>
<td>Formal</td>
</tr>
<tr>
<td>Distinction</td>
<td>Highly satisfactory understanding.</td>
<td>M2</td>
<td>M2</td>
<td>R2</td>
</tr>
<tr>
<td>Credit</td>
<td>Quite satisfactory learning, with understanding at a declarative level.</td>
<td>U2</td>
<td>U2</td>
<td>M2</td>
</tr>
<tr>
<td>Pass</td>
<td>Understanding at a level that you warrant a pass: Salvageable higher level attempts.</td>
<td>R1/U2</td>
<td>R1/U2</td>
<td>U2/M2</td>
</tr>
</tbody>
</table>
In each section, it was determined that the transition into SOLO second cycle thinking needed to be evident for a Pass grade to be achieved. Second cycle thinking involves mastery of metalanguage and a capacity to integrate the various features of the concept into some more generalised frame of reference rather than merely providing a list of unconnected features. Second cycle responses were able to move familiarly within the overarching philosophical and pedagogical principles of both models, making the transition from what was involved in each model to the philosophical and pedagogical rationales of each model and how they were to be applied. First cycle responses, on the other hand, resembled a narrative expression of internal experiences with TGfU and SE, often clumsily written that struggled to engage and control the metalanguage associated with each model. Accordingly, the cut-off for a passing grade was salvageable attempts at R1 responses with some evidence of U2 thinking.

Conclusion
The use of Pegg’s two-cycle approach to SOLO enables effective discrimination between levels of student achievement at a tertiary level. Assessment tasks using this design effectively describe and categorise all levels of student achievement. SOLO in its two-cycle version lends itself to the use of traditional university grading systems by providing justifiable cut-off points based on levels of demonstrated depth of understanding. This project supports Boulton-Lewis’s (1998) contention that SOLO provides an ideal tool for assessing deep learning, here applied to the area of TGfU and SE which have been shown to present difficulties in depth of understanding and application to pre-service teachers of Physical Education.

References


