

Dick Frizzell

By Kevin Collis
University of Tasmania
and
John Biggs
University of Newcastle, NSW

Quantity and Quality

Finding out how *much* your pupils know – how many points they can recall, the number of words mis-spelled, the number of problems solved correctly – this is comparatively easy and there is an elaborate technology of tests and statistical analysis to help. This is by far the most common form of evaluation, even in areas such as essay grading.

An extremely common form of essay marking, for instance, is to award some sort of mark for each relevant point made. That is the 'how much' part of the calculation. Then an adjustment for overall 'quality' is made at the end, and (with some private calculus) both are converted into a final mark.

Typically, then, we mark for quality as well, but do it in quite subjective ways. Apart from the weighting in the final mark, quality is assessed and communicated by the following kinds of comments that appear at the foot of the essay: 'Your argument is faulty, Dick, you must learn to stick to the point. 5½/10'; or even, 'A poor quality essay, Jane. Try harder. 4/10'. Such evaluation is uninformative and little help towards improvement. In mathematics, an assessment of quality is often made by reference to the 'elegance', or 'economy', of a solution. In neither case however, is there a general framework for *systematically* assessing *quality*. This is what the Solo Taxonomy provides.

The SOLO Taxonomy

This classification system describes the growing complexity encountered when mastering a task. It can be seen in infants learning to handle a toy, in school-age children mastering content taught to them in school, and in undergraduates coming to grips with understanding a new theory.

- *First*, there is preliminary preparation, but the task itself is not attacked;
- *next*, one, and then, several, aspects of the task are picked up (but in a serial or unrelated manner);
- *then* these several aspects are integrated into a coherent and interdependent whole;
- and *finally* (and only sometimes), that coherent and interdependent whole is generalized to a higher level of abstraction.

We can use the SOLO system to assess the quality of work children have already done, to make a decent job of the essay marking mentioned above, for example. Or we can use the system to design tests which test for quality. The first use can be thought of as an open-ended mode, the second as a closed mode.

Example 1

Open ended mode (work already done)
The SOLO analysis of a process skill

WORD ATTACK IN READING

Preliminaries: when children meet new words they may try

- (a) to immediately visually recognise it (look and say)
- (b) to sound out the letters (phonic analysis)
- (c) to pick up clues from surrounding grammar, meaning, pictures (structural analysis)
- (d) to take the word apart into recognisable pieces (roots/affixes)
- (e) to give each letter name (spell out)
- (f) to use no one method consistently.

Using the SOLO Taxonomy these attack methods are categorised thus:

Prestructural.	No consistent approach. Words are attacked once only, and by any of the strategies.
Unistructural.	One strategy used consistently; it either works or it does not.
Multistructural.	Words attacked by several strategies if the first one fails, but no attempt to 'orchestrate' strategies to suit the word.
Relational.	Selective use of strategies to suit the nature of the word, e.g., single syllable words sounded out (b), polysyllables taken apart (d).
Extended abstract.	Formulating principles to guide strategy selection.

Note that using a 'higher' level of thinking does not guarantee better results.

Method/Results

Nine-year-old pupils were given the St Lucia Graded Word

Reading Test. Pupil 2, using only the phonic strategy (SOLO: Unistructural), was able to read more words correctly than Pupil 4 who had mastered several strategies (SOLO: Multistructural). The pupils had all been taught several attack methods but some pupils seized hold of one method and used that until it was well mastered before adding to their repertoire by using other methods; others tried out several methods, occasionally with 'poorer' results. (Such results raise many interesting questions about the acquisition of reading strategies.)

Discussion

As you will have noticed the SOLO (Structure of the Observed Learning Outcome) system is dealing with levels of abstraction. Children are not only busy learning facts but also how to deal with them – ways of organising their own concrete experiences and ideas introduced to them by teachers. This article is particularly concerned with structural growth (learning) as it applies to content matter (facts) at the level of abstraction (ideas) met with by school-age children. Some readers may recognize a similarity with the stages of cognitive development proposed by the psychologist Piaget, and up to a point, they would be correct. Perhaps a word should be said about this to clear up a possible confusion.

We in fact started out using Piaget's framework in order to map how children tackled various school subjects. We quickly found that children did not advance evenly through Piagetian 'developmental' stages. What was thought to be evidence for developmental stages is better interpreted as indicating levels of *learning* competence. This shift in meaning is highly significant for teachers. When we say that a student is at a certain level in the SOLO Taxonomy (in a given task) we mean simply: the student has gone that far in learning that task at that time; there is no implication that further progress may not be made. However, the Piagetian levels imply that the student will not progress to the next level of complexity until some maturation – often requiring several years – has taken place.

General SOLO Structure

The general structure that underlies the SOLO Taxonomy is outlined in Figure 1.

Lower level responses are either dogmatically 'closed', or indecisive. At the highest end, extended abstract responses are often qualified, leaving room for different interpretations and mitigating circumstances.

Transitional responses have not been described. These are responses that share something in common between two levels. There is no space here to elaborate on transitional responses, but the general argument remains the same.

The SOLO taxonomy in action

In the first example we showed how the analysis of how a child tackled a task could lead to a judgement of quality. Such analyses can be made of all work involving complex processes or skills, for example creative writing or mathematics. It can also be used when the task that has been set involves the drawing of conclusions from a lesson, from text, diagrams, film, etc. Our second example is one of these.

Figure 1:
The SOLO Taxonomy

Level	Structure	Response
<p>5 Extended abstract</p> <p>Several conclusions are possible. Abstract principles are used to interpret concrete facts, and the correct response depends upon context. Consistent.</p>	<p>A</p> <p>A</p> <p>A</p> <p>-----</p> <p>C</p> <p>C</p> <p>C</p> <p>-----</p> <p>P</p> <p>P</p> <p>P</p>	<p>R₁</p> <p>R₂</p> <p>R₃</p>
<p>4 Relational</p> <p>The response is based on an integrating concept, relating to all the relevant details. The conclusion sticks to the given context. Internally consistent, but not from context to context.</p>	<p>A</p> <p>A</p> <p>A</p> <p>-----</p> <p>C</p> <p>C</p> <p>C</p> <p>-----</p> <p>P</p> <p>P</p> <p>P</p>	<p>R</p>
<p>3 Multistructural</p> <p>The response is based on a few concrete details but without thinking about how they inter-relate. Consistent, but elements not integrated, may change from time to time.</p>	<p>A</p> <p>A</p> <p>A</p> <p>-----</p> <p>C</p> <p>C</p> <p>C</p> <p>-----</p> <p>P</p> <p>P</p> <p>P</p>	<p>R</p>
<p>2 Unistructural</p> <p>The response is based on one concrete fact that the student has seized upon. It is usually consistent, but with only one element, and it may change from time to time.</p>	<p>A</p> <p>A</p> <p>A</p> <p>-----</p> <p>C</p> <p>C</p> <p>C</p> <p>-----</p> <p>P</p> <p>P</p> <p>P</p>	<p>R</p>
<p>1 Prestructural</p> <p>The response is based on an irrelevant detail that has struck the student's fancy. It is personal and subjective, lacking intrinsic organisation. Usually contains inconsistencies.</p>	<p>A</p> <p>A</p> <p>A</p> <p>-----</p> <p>C</p> <p>C</p> <p>C</p> <p>-----</p> <p>P</p> <p>P</p> <p>P</p>	<p>R</p>

Key 'A' related abstract principle; 'C' concrete fact, as given; 'P' pre-relevant detail.

Example 2

Open ended mode (work already done)

The SOLO analysis of a content task

CONCLUSIONS FROM A HISTORY LESSON

Preliminaries: a class of 14-year-olds was given a unit of work, including a debate, on the role of squatters in Australia's history. The students were then asked: 'What reasons did the squatters have for defying the government's regulations? Were they justified?' The following responses are selected to illustrate each of the five levels:

Prestructural. 'None. They defied the government'.

Unistuctural. 'Yes, because they were helping to develop the wool industry'.

Multistuctural. 'Yes, the squatters were justified because there was better pasture land outside the limits of location and another reason was that the wool industry would grow'.

Relational. 'No, I don't think the squatters were justified because although the price of land was too high and they did not have enough security, it was wrong to go and just take over the land without permission; laws are made to be kept by the public.'

Extended abstract. 'It depends upon how wide a term you want "justified" to be. In a restricted sense you could say the squatters were not justified because the government saw a need to develop and focus its resources in a known rather than an unknown area. If you widen the term, you can say that squatters felt themselves to be justified, since they emigrated so that they could own land ... by hard work and occupancy they felt they had made the land their own ... in the long term, the wealth of the Australian colonies rested on the productivity of the squatters.'

There is a clear progression here in complexity of structure of the responses, from the banal repeating of the question in the first response to an almost philosophical discussion of the nature of justification in the last response. The unistuctural and multistuctural responses seize upon one and two aspects, respectively, to 'close' the case; neither respondent admits to a conflict or to any alternative. The relational response admits there is a conflict, but firmly resolves it by an appeal to the law. Only in the extended abstract response is there any attempt to get beyond the concrete instance of time and place, and the need to take different perspectives into account.

The SOLO taxonomy and testing

So far we have looked at how the SOLO Taxonomy may help teachers discern the quality of work already done. Let us now turn to the use of the SOLO technique in its more closed form. Essentially the technique is used in reverse, to design test items. The aim is to ask a series of questions about a stem (some information) in such a way that satisfactory responses require a more and more sophisticated use of the information in the stem. This increase in sophistication should parallel the increasing complexity of structure in the SOLO categories.

Suggested here are steps to writing a stem and 4 questions which reflect the four SOLO levels, unistuctural, multistuctural, relational and extended abstract. If no attempt or an inadequate attempt is made on the first two questions the level can be assumed to be pre-structural.

Writing the stem means providing necessary and sufficient information to ask a range of questions about something relevant to the subject. Writing the questions requires suitable criteria: the four questions must require a knowledge of the subject and each be at one SOLO level. The following criteria have been used to design questions at each SOLO level:

1. Unistuctural: Use *one obvious* piece of information coming directly from the stem.
2. Multistuctural: Use two or more discrete and *separate pieces* of information contained in the stem.
3. Relational: Use two or more pieces of information each directly related to an *integrated* understanding of the information in the stem.
4. Extended Abstract: Use an *abstract general principle* or hypothesis which can be derived from, or suggested by, the information in the stem.

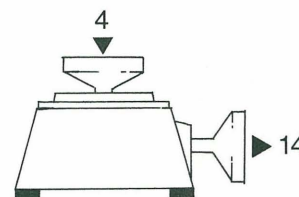
Example 3

Closed mode (making up a test)

Four questions in SOLO level order

MATHEMATICS

This is a machine that changes numbers. It adds the number you put in three times and then adds 2 more. So, if you put in 4, it puts out 14.



- (U) If 14 is put out, what number is put in?
- (M) If we put in a 5, what number will the machine put out?
- (R) If we got out a 41, what number was put in?
- (E) If x is the number that comes out of the machine, when the number y is put in, write down a formula which will give us the value of y whatever the value of x .

The stem provides all the necessary information and each question requires reasoning at a different level.

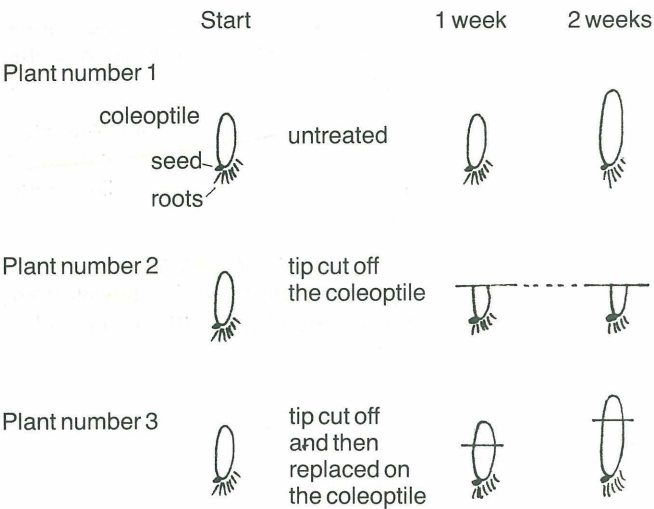
- (U) Answer: 4. One piece of information used, one answer required, the information is obtainable from either the last sentence in the stem, or from the diagram. This is the unistuctural response level.
- (M) Answer: 17. All the information is used in a sequence of discrete answers. The stem is seen as a set of instructions to be followed in order. This is the multistuctural response level.
- (R) Answer: 13. All the information is used but, in addition, the student has to extract the principle involved in the problem to solve it – in this case to use it in reverse. This is the relational response level.
- (E) Answer: $y = 3x + 2$. The student has to extract the abstract general principle from the information and write it in its abstract form. This involves dismissing distracting cues, perhaps forming hypotheses and testing them, and zeroing in on the relationships involved. This is the extended abstract level.

Example 4

Closed mode (making up a test)
Four questions in SOLO level order

SCIENCE (Biology)

Three oat seeds were germinated. The coleoptiles were then treated in the following way:



Plant number	Start	Height at 1 week	2 weeks
Plant number 1	1	2	2.5
Plant number 2	1	1.4	1.4
Plant number 3	1	2	2.5

- (U) Which oat seedling had the tip cut off its coleoptile and not replaced?
- (M) What is the height difference after two weeks between the seedling which had its tip removed but not replaced and the seedling which had its tip removed then replaced?
- (R) How does the coleoptile tip affect the growth of a seedling?
- (E) Develop a general hypothesis which could have been tested by the above experiment, and list three other factors which would need to be controlled.

To answer the unistructural question, the student needs to understand the information only sufficiently to select one specific fact. At the other end of the scale, in the extended abstract question, the student must go beyond the information to thinking through abstract principles and possibilities.

Example 5

Closed mode (making up a test)
Four questions in SOLO level order

HISTORY

Below is one view of the conditions in Britain in the 1830s. Read it and then answer the questions which follow:

Factory workers are working from 3.00 a.m. until 10.00 p.m. for three shillings and seven pence halfpenny, a quarter of

which they lose if they arrive five minutes late for work. Children of 6 years old are working in these factories under the most atrocious conditions. The overlookers often beat their workers but no compensation is paid for injuries received at work. The workers' houses consist of one room with an earthen floor. These houses are packed tightly together around the factory and this together with lack of proper sanitation make for very unhealthy, in fact, dangerous conditions.

- (U) Name one aspect of a factory worker's lot that you believe was unsatisfactory.
- (M) List four problems that existed in the factories of those days which would not be tolerated today.

Another writer of the same period described the conditions in Britain in the 1830s in the following way:

The working classes in Britain, though they have their grievances and distresses, are, on the whole, better off as to physical comforts than any other European working class. They have a more plentiful supply of food, better clothing, and better furniture and for this reason suffering is more acutely felt. Yet we firmly believe that, in spite of heavy taxation, a war, and a huge public debt, the country is becoming richer and richer.

Consider the two views given above of the conditions in Britain in the 1830s in answering the following questions:

- (R) How can the facts in each statement be related to one another?
- (E) Two writers, writing at the same time about the same set of conditions, apparently come to entirely different conclusions. How can you account for this?

Curriculum

The principle of *levels* of attainment is used in higher public examinations. A 'level' is defined partly on the amount of work required, and partly on the kind of understanding or skill required. The SOLO Taxonomy provides one means of making it possible to discuss, and test, the quality required at different levels. For example, it would seem perfectly adequate if many students at year 10 or 12 were able to understand the basic concepts of a particular subject and the inter-relationships involved; that is, if they were able to respond at the SOLO level called Relational. Indeed, for some students a listing of essential facts at the multistructural level is probably all that is necessary. Multistructural understanding is probably the best that can be hoped for by the end of primary school.

A useful first step, then, would be agreement among curriculum specialists about suitable tasks, both content and process for different year levels; following that there needs to be a survey among schools to see what are reasonable goals.

The next step is for each teacher to analyse what he or she has decided to teach into the components that make for adequate understanding. In a process task, the components are skills and strategies that have to be deployed; in a content task, the ideas the writer is trying to express, the concepts to be learned and inter-related, and so on. Such analyses are very useful and most readily accomplished working together in small 'workshop' groups.

Evaluation

The SOLO Taxonomy can be applied to criterion-referencing and formative feedback. Criterion-referenced tests are easy to construct when the criterion is the amount learned, but very difficult when the criterion is the quality of learning. In fact, when marking for quality, one usually slips into a norm-referenced or comparative procedure: 'This essay is better than that, and so it should get a B.' It frequently boils down to rank ordering essays along some complex and usually unstated continuum and then deciding the cutting points between final marks, after the event.

SOLO provides a relatively stable means of making decisions about quality independently for each essay. Because SOLO has a structure and a vocabulary the teacher can talk about it, and can thus make the marking system explicit to students who query their grades: 'Sure you have as many points down as Bill, but he has inter-related them, you see...'

SOLO applies to question-setting. 'What are the main factors in...' is a question that requires no more than a multistructural response. The teacher should not be disappointed, therefore, if that is the level at which the answers come back. 'Compare and contrast...', on the other hand, minimally demands relational responding. By the same token, extended abstract responses could be marked down on the grounds of irrelevance, or lack of attention to detail. In short, the SOLO Taxonomy can help the teacher decide what is wanted in the way of quality, and communicate that desire to the students.

Teaching

Can higher level responding be taught? This is an issue hardly yet investigated. The transition from uni- to multi-structural is a simple case in point. If students impetuously seize upon the thing that strikes them first, they will miss other important data and their answers to questions will be unistructural. If they were trained to hold back and scan the information more reflectively would that result in a higher level response? Similarly, it may be possible to teach strategies for marshalling the case for, the case against, and then searching for a relating concept. This may help the pupil to make the transition from multistructural to relational. The overall strategy here is like the 'Plus One' strategy recommended in values education: teach at just one level higher than the student, and not more than that.

However, high level responding is not just a matter of strategy.

The extended abstract response about the squatters, in Example 2, for example, would not have been possible without a great deal of background knowledge. SOLO Taxonomy is hierarchical: each level builds upon the previous one's content. The teaching problem is thus twofold: to teach content progressively, with particular reference to the key concepts necessary for the higher level integrations (emigrating, settling, squatting, defying the law...); and to teach strategies (scanning, making cases, integrating...), appropriate to handling the content at the SOLO level you are aiming at.

Notes

Dr K.F. Collis is Professor of Education, Dean of the Faculty of Education and Head of the Department of Educational Studies at the University of Tasmania, Box 252C, G.P.O. Hobart, Australia 7001.

Dr J.B. Biggs is Professor of Education at the University of Newcastle, NSW, Australia 2308.

This article introduces the ideas and techniques found in Biggs, J.B. and Collis, K.F., *Evaluating the Quality of Learning: The SOLO Taxonomy*, New York: Academic Press, 1982.

Another source of more detailed information is

Collis, K.F. and Biggs, J.B., Matriculation, Degree Structures and Levels of Student Thinking, *The Australian Journal of Education*, Vol. 27, No. 2, August 1983.

Many more examples of the use of the SOLO Taxonomy are available, some in the writing just mentioned and in

Murdoch, L.H., *The SOLO Taxonomy*, Australian Co-operative Assessment Programme, Social Studies/Social Learning, Topic Guide No. 3, Melbourne, ACER, 1982.

and

Biggs, J.B. and Collis, K.F., The Psychological Structure of Creative Writing, *The Australian Journal of Education*, 26, 1, April 1982.

Examples in science teaching can be found in

Collis, K.F. and Davey, *The Development of a Set of SOLO Items for High School Science*, University of Tasmania and the Education Department, Tasmania, 1984.

and

Pallet, R., *SOLO Taxonomy in Teaching Science*, Tasmania: Mathematics/Science Resource Centre (229 Campbell Street, Hobart, Tasmania 7000), 1985.

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