In Search Of A Learner-Control Paradigm For The Solomon Islands Science Classroom

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Abstract

This paper describes concern in Solomon Islands over the difficulties experienced by students studying science at regional universities. It is suggested that this is due to a strong background of teacher-control, minimising the student's ability to function independently in the tertiary science learning environment. A review of literature establishes current support for student control over learning, and describes various levels at which the teaching of learning strategies and metacognitive control by students have been shown to be successful in enhancing meaningful learning. Suggestions are made for the introduction of a learner-control paradigm into the Solomon Islands science curriculum.

Introduction

Until recently, all Solomon Islands students gaining government scholarships to regional universities were graduates of the Form 6 year at King George VI National Secondary School in the capital, Honiara. The Form 6 curriculum was originally based on the Cambridge senior syllabi, and senior mathematics and science teachers at King George VI School have traditionally been experienced teachers contracted from the U.K. Due to the competitive promotion system practised in the Solomons, Form 6 students have always been recognised as being the 'cream' of Solomon Islands academic talent, being the top one percent of those who complete primary school.

Nevertheless, despite this combination of highly-able teachers and pupils, well-equipped laboratories and a relative abundance of teaching resources, a serious deficiency in senior mathematics and science education has become evident in the attrition rate of Solomon Islanders studying the natural sciences at regional universities.

Although documentary evidence is not available, anecdotes feeding back to the schools and the Ministry of Education and Training indicate that a sizeable proportion of Solomon Islands' first-year science students at the University of the South Pacific, The University of Papua New Guinea, P.N.G. UNITECH, and Capricornia Institute of Advanced Education have either failed or performed poorly in first semester science subjects, following which they have frequently given up and transferred to other faculties (e.g. arts, commerce) where they have coped significantly better.

As a direct result of this, there has been a continuing dearth of Solomon Islanders with science degrees, and a desperate need for nationals to work in areas such as maths/science teaching, environmental science, marine biology, industrial chemistry, medical science, information technology and engineering. This in turn has propagated reliance on foreign recruitment of professionals. Recent talk of establishing a university in Solomon Islands appears to presume that virtually all science academics would have to be expatriates: to the author's knowledge not a single Solomon Islander has yet earned a research doctorate in any of the natural sciences.

In 1986 the Solomon Islands Ministry of Education and Training sent the Heads of Science and Mathematics at King George VI School to two regional tertiary campuses (U.S.P., Suva and Capricornia Institute, Rockhampton) to investigate the reasons why students were failing to return with science degrees. Their report (Fradd and Crawford, 1986), apart from describing sociocultural adjustment difficulties common to all Solomon Islanders studying overseas, identified the following factors affecting science students' ability to pass first-semester subjects:

- poor note-taking ability
- poor problem solving ability
- poor time management skills
- inability to present logical arguments, especially to challenge propositions presented by lecturers
- inadequacy of written and spoken English
- lack of confidence to speak up in tutorials.

Fradd and Crawford concluded:

> *Finally, it is a sad fact that a country of a quarter of a million people finds difficulty in sending as few as fifty students a year capable of tackling a university course. This reflects badly on the education system of the country from primary schools upwards. The Sixth Form syllabi at King George VI School are an excellent preparation for university, particularly the U.S.P.*
>
> *"If a house falls down, look at the foundations, not the roof."*
>
> *(Fradd and Crawford, 1986, p. 7)*

In this paper I will follow through on this recommendation to 'look at the foundations'.

An Analysis of the Problem

Undergraduate science students require a broad range of cognitive and metacognitive skills in order to achieve course objectives. Dozens of control decisions are necessary to complete each learning task. During lectures, the student must make metacognitive decisions for note-taking: which information is to be taken down, and how to divide attention between listening and writing. Devising and sticking to a time management programme is an executive control process. Selecting useful readings from a bibliography, skimming through text, extracting information from tables, writing theoretical essays and practical reports, carrying out acid-base titrations or sketching an organism under the microscope: all require constant metacognitive monitoring to optimise meaningful learning and performance. Writing a critical literature review not only requires interpretation of text but evaluation of its contribution to scientific knowledge. Many courses today assess students on their contribution to tutorial sessions and seminars where they are expected to take part in academic debate and evaluative discussions of experimental findings.

Most of these skills require the tertiary student to be in firm control of his cognitive learning processes. He must be aware of what he is doing, and, more importantly, why he is doing it. If the undergraduate's experience of science education has been limited to the passive acquisition of propositional knowledge by copying detailed blackboard notes, he will obviously find it difficult to cope with the necessity that he take responsibility for his own learning at university.

Observations made during my experience of teaching science at both King George VI and Waimapuru National Secondary Schools led me to believe that Solomon Islands secondary students generally do not acquire the executive metacognitive skills and active learning strategies required for coping with the independent learning required in a tertiary science faculty. Further, I have observed that attempts by the secondary science teacher to introduce independent learning strategies and metacognitive control processes in the classroom are met with student resistance. Strong preference for passive, non-participatory learning styles is prevalent throughout all form levels.

The source of this preference for teacher- controlled learning appears to be found in the cognitive entry characteristics of incoming Form 1 students. Students enter secondary school in the Solomons replete with deeply ingrained habits and expectations which are tell-tale of a teacher-centred model of learning in the primary school classroom.

Many habitual behaviours of students - relating generally to classroom procedures, undertaking group activities, presentation of written work, and interaction with the teacher - are incompatible with the enquiry process crucial to science. Despite concerted effort on the teacher's part, carry-over primary school behaviours prove difficult to alter. The following descriptions of typical Form 1 student characteristics are based on my and colleagues' experiences:

> * Form 1 students are extremely resistant to any change in method of setting out written work. For example many write "answer" or "ans" after the solution to every maths problem. Despite being told that this is unnecessary ("the number after the last `=' sign is always the answer"), this and similar behaviours tend to be robust.
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> * Independent research assignments and discovery learning projects result in anxiety and complaints from students. Incoming Form 1 students have poor library skills and find it difficult to locate

information.

* Junior students are less than gratified by a science lesson unless the teacher bases it on 'chalking and talking': delivering a structured lecture while simultaneously chalking detailed notes. They exhibit anxiety if a complete written transcript of the lesson is not provided for copying into their workbooks to be rote-learned.

* If the science teacher leaves blanks or offers alternatives in place of keywords in class notes, students will leave spaces in anticipation of being told correct answers. If at the end of the lesson the teacher still insists they search for their own words to fill the blanks, many students leave the room in a state of anxiety.

* In mathematics, students' full attention is always given to copying a worked example from the blackboard while the accompanying didactic explanation is often ignored. Students leave the classroom satisfied with their written record of the lesson, but at evening study find they can't follow the reasoning required for independent prob lem-solving.

* At times when it is perceived that the teacher is 'teaching' the class, students are resistant to being lured into asking or answering questions, offering observations or suggestions, or any other participation than attending to the teacher and the blackboard.

* Students generally do not perform well when working in groups. Students based at the same laboratory workstation frustrate the cooperative purposes of group work by asking the teacher for advice or assistance before consulting others in the group. Often one or two students conduct the exercise while others in the group either look on or copy out the instructions.

By the time the average student begins senior science (Form 4), he or she is characterised by:

-inability to cope with multi-media stimuli

- inability to analyse or criticise presented information or generated data

- tendency to amass propositional knowledge without forming sufficient supportive concepts

- inability to reason according to the scientific method

- lack of interest in scientific careers, particularly research.

From my observations of student behaviours, I am led to conclude that the incoming Form 1 student views the classroom as a locus of teacher control, and assumes that the teacher is to bear most of the responsibility for his academic success ('learning'), while his own small duty lies in conscientious recording of information, and faithful rote-learning of notes and examples. It is evident that the Form 1 entrant has little concept of being able to potentiate his learning through his own control.

These essentially uniform entry characteristics probably result from the combined influence of cultural learning styles and learning behaviours ingrained at primary school.

Recent work by Peter Ninnes (1991) has identified four main traditional learning strategies used by Western Province Solomon Islanders in the village environment for acquisition of tribal ethics and skills:

1 *observation*
2 *imitation*
3 *participation*
4 *listening*

Ninnes identifies two primary learning contexts: that of the peer group and that of the parents and extended family, and notes that the degree of learner participation in the learning task depends on the context:

Partial participation in [Western Province Solomon Islanders] is most common when children are in the presence of older, more skilful people. Full participation is prevalent, on the other hand, when children are part of a group of relatively equally skilled individuals, such as the peer group. ... Within the peer group there is a relatively high proportion of learning by full participation and a lower proportion by partial participation and observation.
(Ninnes, 1991, pp 242, 246)

It is significant to note the lack of full participation in learning in the presence of elders with greater knowledge. This may explain various student behaviours in the science classroom, such as declining to offer explanations for observations or attempt calculations under the teacher's eye. (Ninnes notes that students will participate more fully in novel tasks in science if the teacher leaves the room or feigns preoccupation with something else.)

In the same study, Ninnes found that while students had difficulty carrying out science experiments from text book instructions and diagrams, the culturally-appropriate teaching methods of *verbal explanation* and *showing* enabled students to learn the techniques. However, when students had a choice between carrying out practical work and copying blackboard notes they tended to opt for the latter. Ninnes claims this is due to their belief that knowledge "arises from external sources" rather than being elicited by their own investigations. He observes that knowledge to the Solomon Islanders is customarily contained in closed systems, which can only be added to and validated by qualified sources such as visions. This makes it traditionally impossible for the average person (especially a child) to discover knowledge for himself.

The externalisation of knowledge sources in Melanesia results in students viewing schools as knowledge sources rather than as sources of intellectual experiences. Consequently, students value passive knowledge acquisition over active knowledge construction.
(Ninnes, *ibid*, p 253)

Clearly there is a dissonance between the traditional Melanesian approach to learning and the process of scientific enquiry which science teachers wish to nurture in their students.

Village schools are heavily influenced by the culture of the locality, and it is intuitive that traditional passive learning styles will be preferred by both students and teachers in a school within the community environment. In addition, there are other reasons why teacher control features prominently in village primary school classrooms:

- very few schools have a full staff of trained teachers: sometimes only the head teacher has a teaching diploma, and the majority are either untrained or have completed only short courses in classroom techniques. Most untrained teachers have only a primary or junior secondary education themselves, and tend to teach in an autocratic style which mirrors their own experience as a student.

- teachers have a minimum of teaching resources available to them: most villages have to support their own schools (provincial governments pay teachers).

- competitive promotion means there is pressure from parents for teachers to focus on preparing students for regurgitating knowledge in the secondary selection exams: only a small fraction of Class 6 leavers are selected for Form 1.

While the primary school learning environment may indeed be valid for training students to pass the selection exams, it appears to do little towards developing the independent thinking skills important for scientific enquiry, which a small percentage of the students will need desperately six years later as they enter a university science faculty.

However, the justification of global curriculum changes to benefit a select few, and the sheer enormity of the teacher training issue and the costs involved mean there is little likelihood of revolutionary change in primary education in the Solomons in the near future. For present purposes I shall assume the cognitive entry characteristics currently perceived in incoming Form 1 students will remain standard for some time to come. It appears that any marriage between students and the scientific process will have to come after entry into Form 1.

What is needed in the secondary science curriculum is a learner-control paradigm which leads the student ultimately to self-activated learning in the tertiary context.

The Argument for Student Control

In recent decades, the concept of student control over learning has gained an increasing research following as the age-old, teacher-centred construct of 'teachers teaching pupils' is gradually abandoned by educators and education researchers alike.

The teacher-centred perspective on classroom learning had a dominant role in the history of education practice and research up until the 1970s. Nathaniel Cantor's (1953) "Nine assumptions to orthodox teaching" lend support to the idea that students can be reinforced into a learned helplessness when - among other behaviours - their teachers act as if they assume that they personally are responsible for the pupil's acquisition of knowledge (Cantor's assumption 6), and that knowledge exceeds learning in importance (assumption 8; Cantor, 1953 pp. 67-70).

Ned Flanders, one of the pioneer researchers on teacher behaviours, summed things up at the end of the sixties when he wrote:

> *...it does not seem very far out of line to suggest that teachers usually tell pupils what to do, how to do it, when to start, when to stop, and how well they did whatever they did.*
>
> (Flanders, 1970 p. 14).

Tyler (1950) was one of the first researchers to propose that learning is a student-centred rather than teacher-dependent phenomenon. He proposed learning to be an active process on the part of the learner, quite independent of the teacher's pedagogical efforts. Work by Bloom (1976) also discounted the quality of instruction as a primary learning control factor, and focussed attention on the preparation and motivation of the learner.

As a result of the gradual change in the research focus from the teacher to the student, the cognitive view of classroom learning has emerged, and with it the imperative that learning hinges on students' internal cognitive processes, rather than external factors such as teacher behaviour or time allocated to learning tasks.

A major foundation for the call for greater student control over learning processes was laid by Wittrock's (1974) generative learning model. Wittrock theorises that students' existing cognitive schemata (prior knowledge) actually interact with presented information to generate new schemata. The model requires that the teacher have some degree of knowledge of the student's existing understanding before attempting to present new information, which the student is then responsible for assimilating into existing knowledge to generate novel conceptual schemata.

Osborne and Wittrock (1983) extend the generative learning model to consider the particular difficulties inherent in science teaching. They view the challenge in science education as being modification of the student's existing robust ideas about the world. Accordingly they have undertaken considerable efforts to elicit precise information about children's pre-held beliefs about science. They find that entrenched ideas about scientific concepts are not only plentiful in children's minds, but also very hard to alter. They observed that even senior science students continue to hold erroneous propositional knowledge (e.g. that boiling water releases bubbles of air), and that even when their incorrect ideas are confronted with contradictory fact they still tend to retain their beliefs. Accordingly Osborne and Wittrock underscore the notion that only the children themselves can alter their own perceptual schemata, and even then only when new information is presented in a convincing enough manner to warrant any changes.

Research also shows that teachers can not only target specific existing schemata in their presentation of new ideas to students, but they can also teach students more effective methods of concept assimilation. Tennyson and Cocchiarella (1986) postulate from the research literature that the formation of conceptual schemata is assisted by teacher provision of a best example of the concept, and practice at using the best example with variant examples. By searching out a best example (if not provided) and practicing using this to refine the concept (if feedback is available), the student can assume some degree of control over concept formation.

The benefits of such student-control over knowledge aquisition were demonstrated by Larkin and Reif (1979), who taught students how to extract information from text problems (i.e. how to form perceptual schemata) and showed that these students were better able to solve relational concept problems. They also found that training given in the concept of physics problems was transferable to another area of the curriculum (economics).

Students in executive control of learning processes (such as recognition of task goals) also perform better than other students. Meece, Blumenfield and Hoyle (1988) and C. Ames and Archer (1988) in separate studies underlined the fact that students who perceive and pursue mastery goals in the classroom are liable to be more active in the engagement of effective cognitive strategies. Russell Ames (1983) concludes that students who have themselves assigned clear, attainable goals to learning tasks are also more likely to seek help when required. Kinzie and Sullivan (1989) report salient continuing motivation in students who had undergone a training program in learner executive control. There is no doubt that students who are taught to identify the purpose of a learning task, its components and the most efficient way of going about mastering them, become highly motivated independent learners. Bloom even goes so far as to imply that with such learners it makes little difference how good (or bad) the teacher's methods are; they can continually outperform dependent learners (Bloom, 1976 p 134).

The actual teaching of learning strategies and metacognition presumes the breakup of knowledge into different types, each of which may be acquired using different skills. Evans (1988) outlines popular division of knowledge into:

-propositional knowledge (facts and proposals)

-procedural knowledge (including automatic responses, specific procedures and higher order processes)

-executive control

-monitoring

He points out that proficiency in the management of each of these cognitive domains is not only adaptive for school achievement, but a lifelong investment given the number of post-school learning tasks which confront us in the age of technology.

Weinstein and Mayer (1986) review progress in the teaching of learning skills developed through task analysis, and categorise learning strategies into the areas of *rehearsal, elaboration, organizational, monitoring and motivational.* A comprehensive learning skills program would incorporate instruction in strategies from all of these domains, and probably include practice in word-pair associations, mnemonics, paraphrasing, underlining, drawing diagrams, ordering, self-questioning and thought discipline. The teaching of learning skills is a labour-intensive exercise and generally most cognitive strategies require practice under instruction to be adequately mastered.

Evans (1988) notes the *detached* vs *embedded* approaches to the teaching of learning skills, and the prevalence to date of the detached study skills curriculum which has been disconnected from the rest of school learning in terms of both class location and target material. The teaching of learning control strategies as an integral (i.e. embedded) part of everyday classroom subject teaching is an ideal which requires total commitment by the teacher (and the school) to the learner-control paradigm. Maher and Schwebel (1986) succinctly summarise the major resistance to commitment to the development of cognitive skills:

> *Some teachers using traditional instructional material do occasionally stimulate thinking in classroom discussion or in the solution of problems. For the most part, however, this activity is incidental to the main purposes of the school. The stimulation of thinking has not been and is not now a conscious goal of schools*
>
> (Maher & Schwebel, 1986 p.195)

Implications

The foregoing survey of literature may be summarised by the following propositions:

1 Students find it easier to assimilate new ideas when teachers aim presentations at their existing knowledge base.

2 Learner-centred learning is more effective than teacher-centred learning.

3 Students can be taught learning strategies. These might be rehearsal strategies, note-taking skills, or executive control procedures.

4 Students who use learning strategies perform better on learning tasks than students who don't.

5 When students recognise themselves to be in executive control of learning, or when they perceive mastery goals set by the teacher, they have greater motivation for the task at hand.

Two crucial implications of these propositions are generally absent from the junior science classroom in Solomon Islands:

> 1. *The targetting of new teaching material at the level of students' prior foundational knowledge.*
>
> 2. *The teaching of learner-control skills (both for the acquisition of knowledge and the control of executive /meta-cognitive procedures).*

The tailoring of new science teaching material to students' established schemata is a relatively simple matter in the higher forms, as there is a common curriculum taught in all secondary schools from year to year, and promotion to the next form level is conditional upon satisfactory achievement of learning goals for the previous year. Appropriate targetting of new material is the responsibility of the classroom teacher, and those with some experience are able to do so very competently.

Difficulty arises with Form 1 students, who enter secondary school from a broad range of educational backgrounds: those from Honiara primary schools have had considerable exposure to science both at school and through the media, whereas others from remote village schools are likely to interpret natural phenomena in terms of 'custom stories' (myths and legends). The majority of students entering Form 1 in the Solomons' 20-odd secondary schools every year probably understand the operational principles of the world around them considerably more erroneously than some of the children encountered by researchers in Western countries, such as Osborne and Wittrock (1983). Any serious attempt at addressing deficiencies in science education in Melanesia must include a study on children's ideas about science. It may well be that the gap between the knowledge of the village primary school student and the content of the secondary science syllabus is so huge that students shy away from attempts at assimilation of concepts which might be opposite in nature to what they already believe (e.g. assimilation of the theory of evolution with traditional creation beliefs).

A research study on Class 6 students' ideas about science appears to be an urgent need, the results of which would assist Form 1 teachers with their targetting of new material, enabling students to more easily assimilate new concepts with old: an important first step on the road to learner-control.

Any proposal to teach specific learner-control skills is unlikely to gain widespread support in Solomon Islands in the short term due to prevailing attitudes in the greater educational community. By and large, Solomon Islanders who have studied in the fields of humanities, commerce and applied technology at overseas universities have done well, and gone on to become successful community figures. Hence the notion that the education system is functioning satisfactorily is generated, and the poor performance of undergraduate science students is often put down to personal failure and swept under the mat. It is unlikely that global reforms of the national curricula to include metacognitive skills training will be initiated as long as it is perceived that science is the only area not performing under the 'otherwise-successful' current system. My suspicion is that a problem perceived as being exclusive to science will be left to science teachers alone to address.

Fortunately, the introduction of science classroom reforms in Solomon

Islands is not unrealistic due to the function of the Science Curriculum Panel. All science teachers in Solomon Islands are automatic members of the Panel, which advises the Ministry of Education and Human Resources Development on science curriculum issues. While the Government has the ultimate say over curriculum content, the Science Curriculum Panel's recommendations represent the best advice available to the Minister and are generally rubber-stamped. Strategies for implementation of the curriculum are left entirely up to the science teachers themselves, and are discussed at fortnightly Panel meetings in Honiara during term. Decisions made at meetings are recommended for implementation in all Solomon Islands science classrooms. Collectively, science teachers in Solomon Islands are chartered to teach the science curriculum in such a way as they judge will maximise the performance of their students, both in the short and long term. Solomon Islands teachers are the envy of their peers in many a neighbouring country, to have such a direct say in what science is to be taught in schools, and how.

Within the Panel framework, it is entirely feasible for science teachers to introduce their own programme for the teaching of metacognitive skills and learning strategies.

Learning strategies may be taught within the context of normal subject teaching (embedded) or in separate classes (detached), the latter being the common practice in most schools promoting student control (Weinstein & Mayer, 1986). White (1986) however has proposed embedded teaching of learning strategies to be more effective, emphasising the importance of relating executive control procedures to the immediate tasks at hand.

The detached approach to the teaching of learning strategies is not a viable proposition for science departments in Solomon Islands schools. Already strained by an eternal shortage of trained staff and daily timetables bursting at the seams, schools are unlikely to attract domestic funding for 'extra' subjects.

The alternative and realistic option is to implement embedded teaching of metacognition and learning strategies by in-service training of existing science teachers.

If the Science Curriculum Panel were to commission a study to identify the critical learning skills lacking in Solomon Islanders entering tertiary science programmes, a list could be drawn up of specific strategies and skills which need to be taught within the secondary science curriculum. The Panel could then look at various ways of subsuming the teaching of these strategies and skills into everyday science lessons. This could mean writing a new draft curriculum, or publishing addenda for each existing form level syllabus.

Systematic teaching of metacognitive control processes and active learning strategies throughout the secondary science curriculum would equip students with six years of preparation for independent learning in a regional science faculty. Such a student-control paradigm would undoubtedly empower Solomon Islands students for the challenge of undergraduate science studies, and hopefully give the nation a greater return on its investment in education.

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