CHAPTER 3

THE TYRANNY OF THE TEXTBOOK: DESPITE A NEW SYLLABUS THE SCIENCE TEXTBOOK STILL DOMINATES TEACHER PLANNING AND PEDAGOGY

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Abstract

This study was initiated to investigate the ways that middle school science teachers planned, implemented and assessed units of work developed for a curriculum underpinned by inquiry and outcomes. Our goal was to identify the planning needs and professional support that teachers required to move from an emphasis on content delivery to a curriculum focused on conceptual outcomes. To achieve this, we worked with a group of teachers to plan and implement a unit of science work written for the new curriculum. The teachers set out to plan from the outcomes-based syllabus, implement an inquiry-based unit of science, and assess it using an open-ended task. During planning and implementation, the teachers were faced with challenges that they needed to resolve to meet the school's expectations for assessing and reporting. The school reporting structure was designed to provide an overall achievement in science and this was calculated from numerical grades. Thus, the teachers felt constrained to teach from the textbook and use assessment practices that assessed the textbook content. We claim that inquiry and outcomes-based units of science work need to have learning experiences, and assessment and reporting structures that harmonise with each other. A more critical approach to the textbook and greater confidence with open-ended assessment may have produced pedagogy and assessment more congruent with the new curriculum.

INTRODUCTION

Between 2000 and 2002, schools in Queensland, Australia, phased in the *Science: Years 1 to 10 Syllabus* (Queensland Schools Curriculum Council, 1999). The new curriculum promoted inquiry and assessment of learning in terms of conceptual outcomes framed by what students know and can do. For teachers, this meant moving from a content-directed to an outcomes-based curriculum. The challenges faced by a classroom teacher included designing units of work that catered for the increased focus on student inquiry (called 'working scientifically' in the syllabus), and designing

assessments which enabled them to identify the outcome level that students had demonstrated. The new science syllabus was designed to provide opportunities to help reverse the declining numbers of students choosing science subjects in senior studies (Dekkers & De Laeter, 2001; Hildebrand, 1989; Speering & Rennie, 1996; Stewart, 1991) by providing the motivation and interest for students to continue science studies.

The previous syllabus documents were published in 1981 (primary) and 1984 (secondary). From 1984 to1999, secondary teachers came to rely on the textbook for direction; in effect it became the de facto syllabus. The science textbook provided the scope and sequence for science teaching in the absence of a syllabus. The vacuum created by the absence of any real syllabus providing direction for science teaching had been filled by science textbooks. When the 1999 syllabus and support materials arrived in schools, the dependence on science textbooks was well entrenched.

The 1999 science syllabus provided the scope (science topics) and sequence (order in which the topics are taught across years 8 to 10) that had been absent in previous years. It also provided a definition of what science should look like in a classroom context, and, although not stated explicitly, provided an implicit explanation of what is meant by scientific literacy. However, the responsibility for juggling the change from the old to the new syllabus and making it 'work' was left largely to the teachers in the classroom. The teachers in this study set about planning a unit of work and assessment that would achieve the aims of the new syllabus, but the eventual implementation of the unit differed from that planned and although it met the requirements of the school reporting system, it did not satisfy the syllabus aims.

Why did this gap between the planning intentions and implementation occur? What challenges occurred during implementation that made it so hard for teachers to implement the inquiry and outcome-based unit of work that they originally planned? There appears to be several factors that challenged the teachers: their beliefs about the nature of science and effective science teaching; their heavy reliance on a science textbook; and their own levels of professional knowledge and confidence with open-ended assessment strategies.

Nichols (2003) observed that when teachers lack formal science training they feel insecure in their personal content knowledge and rarely deviate from the content and pedagogy laid out in the science textbook. This certainly resonates with earlier findings by Bransford, Brown and Cocking (1999) that "[i]n the absence of pedagogical content knowledge, teachers often rely on textbook publishers for decisions about how to best organize subjects for students" (p. 32). Weiss, Pasley, Smith, Banilower and Heck (2003) noted that in 49% of cases the selection of lesson content by teachers

was influenced by the textbook. Half of the teachers surveyed reported "that the textbook has an influence on the content they select for their lessons. In some cases, teachers report following closely the sequence of topics laid out in the text" (p. 79). Students and parents are accustomed to systematic progression through the textbook by the teacher (Glatthorn & Jailall, 2000). The danger with this heavy reliance on textbooks is that textbooks are often filled with facts (Bransford et al., 1999) and conceptual understandings or 'big picture' ideas are not made explicit. As early as 1992, Robertson alerted science educators to this, pointing out that most textbooks present concepts and facts in a linear fashion and "do not show the connections among concepts" (p.56). Also, of considerable concern is that publishers of textbooks focus on traditional topics and avoid those that are controversial in order to appeal to as wide an audience as possible (Marsh, 2004). "Textbooks therefore can have a restraining impact on teachers if they rely heavily on their use in classrooms" (Collins, 2004, p.383).

The classroom teacher remains the critical component in science education reform (Bybee, 1993) and as Connelly and Clandinin (1988) explain, "curriculum development and curriculum planning are fundamentally questions of teacher thinking and teacher doing ... it is teachers' 'personal knowledge' that determines all matters of significance relative to the planned conduct of classrooms." Bransford et al. (1999) found that "any curriculum-[sic] including a textbook-is mediated by a teacher's understanding of the subject domain" (p.151).

At the heart of the issue is Goodrum, Rennie and Hackling's (2001) finding that most middle school science lessons are based on chalk-and-talk teaching, note copying and "cookbook" practical work. Such teacher-centred approaches limit student question-raising and student-controlled investigations. While teacher beliefs about science education may account for some of the difficulties in implementing reform, Lynch (1997) also points to the top down nature of change. A parallel can be drawn to the implementation of the new science syllabus in Queensland. Lynch claimed that the problem was less "one of resistance to change than the lack of a clear image of what change might look like in a ... classroom, exacerbated by practices in schools that often offer few models congruent with reform principles" (p. 7). Faced with an unclear image of what the science syllabus might look like and feel like in the classroom, teachers were easily lured to textbooks claiming to be written in accordance with the new science syllabus. Lynch (1997) found that while some textbook publishers claim to align with the principles of science education reform, little evidence had been found to endorse that claim. Veal's (2001) research highlighted the discordance teachers' perceive between science in textbooks and 'real science' in industry. The teacher participating in Veal's study made the sobering discovery that the textbook would accentuate student

misconceptions about science. A recent study by Reiff (2004) suggests that most science textbooks are out of step with the way scientists work. Scientific inquiry is commonly portrayed in textbooks and in science teaching as the familiar scientific method (Gibbs & Lawson, 1992). Reiff's study highlighted that scientists working in the field did not identify with the models of the scientific method presented in textbooks and do not believe that science textbooks adequately represent the way they do science.

While there is a call for scientific literacy to be a national goal (Longbottom & Butler, 1999), the task of revising science programs, changing teaching practice and developing new assessment and reporting processes is relegated to schools and teachers (Lumpe, Haney & Czerniak, 2000). Fensham (1997) observed that with the amount of support for school science to contribute to the scientific literacy of future citizens, one would expect that supporting pedagogies and assessment procedures would be in place in the classrooms; however, this is not often the case. The importance of teachers in the reform of science education is well documented. Bybee (1993) put it succinctly when he argued that, "the decisive component in reforming science education is the classroom teacher ... unless classroom teachers move beyond the status quo in science teaching, the reform will falter and eventually fail" (cited in Lumpe, Haney & Czerniak, 1998, p.124). Teachers play a critical role in science education; therefore, their beliefs are a key factor influencing science reform agendas (Tobin, Tippins, & Gallard, 1994). However, as Lumpe et al. (2000) found, "the beliefs of teachers are not necessarily consistent with the literature about best practice in teaching" (p.276) but they are stable and resistant to change. Teachers' beliefs about the nature of science influence their pedagogy and the image of science portrayed to their students.

Thus, the quality of the planning decisions made by teachers are crucial to effective science education. Planning provides a basis for understanding how teachers can be instrumental in educational innovation (Sanchez & Valcárcel, 1999). The introduction of the outcomes-based science syllabus provided an opportunity for science teachers to re-evaluate current practices and consider new practices that would harmonize with the new syllabus. The new syllabus provided teachers with an opportunity to aim for relational understanding (Skemp, 1976) rather than instrumental understanding. Instrumental understanding is knowing a rule and being able to use it, but not understanding the reasoning behind it, whereas relational understanding encompasses "knowing both what to do and why" (p.20).

Consequently, this study set out to explore the planning of teachers faced with curriculum change to identify the factors that facilitate and inhibit the development of science literacy in the classroom.

DESIGN AND PROCEDURE

The study was conducted by two researchers over a period of 11 months and involved working with participants in the planning sessions and implementation of the planned unit of work. Data collection occurred over three planned phases of the project, these being the pre-planning and planning phase, implementation of the unit of work, and reflection on the implementation. During the planning phase data were collected through participant observer field notes, taped professional discussions, teacher's planning notes, and semi-structured interviews of participants. The second phase of the study involved the teacher's implementation of the new unit of science and student involvement in the unit of work. Data were collected through participant observation of Anna's class, field notes, taped professional discussions, student logbooks, conversations with students about their work and photographs of student work. The third phase involved gathering data on the teacher's perceptions of the implementation of the unit and their reasons for changes that were made to the unit during implementation. Data on the third phase of the project was collected through semi-structured interviews with both students and teachers, student logbooks, and taped informal discussions with teachers. Field notes were taken at each school visit and used in the interpretation of the data. Qualitative case study method (Guba & Lincoln, 1989; Merriam, 1998; Patton, 1990) was chosen to investigate the planning sessions (one full day), the writing of units of science work (a second full day), refinement of unit and assessment tasks (over three to five weeks) and implementation of an inquiry based unit (five weeks at 3 hours per week). Transcribed notes of taped interviews and conversations were made available to the participants.

The case study centred on one of the participants, Anna (all names used are pseudonyms) and her story is told as a biography. For context, the case adds the actions and opinions of other science staff involved in the development and implementation of the new curriculum program. In particular, the interactions of Anna with the science department head, Glenda, are discussed to portray the constraints encountered by Anna when she attempted to move from a content and teacher-centred approach to an inquiry and outcomes-based approach to science education.

During the planning phase, one author acted as a critical friend, and then latter, as an in-class participant-observer during implementation. The other author also acted as critical friend and supervisor of the project. Planning documents, semi-structured interviews, observations, and taped professional discussions with Anna, science staff and students provided detailed qualitative data. The data were categorized according to the interview themes, and reported and interpreted as a case study. Analysis was underpinned by the literature reviewed and the notion of dilemma (Altrichter, Posch & Somekh, 1993), with a focus on the gap between the

'ideal' (planned) and 'actual' (implemented) science teaching. This dilemma is used to seek insights into the constraints, both real and perceived, experienced by the teachers when attempting to plan and implement units of work based on the new science syllabus. The data were categorized into teacher planning and implementation intentions and actions, and perceived and actual constraints and challenges.

FINDINGS

SCIENCE TEXTBOOK

The teachers in the study had decided that they needed a new science text and their first step in planning for the new syllabus was to choose the new science textbook. When questioned about why they needed a set text, Glenda's immediate response was "for parents". In response to an inquiry as to whether they wanted the textbook to drive what they taught in their science units or did they still want to decide what they taught, Glenda answered that apart from a health and safety unit she would like to add, she was happy for the text to drive what they would teach. In response to a question about the characteristics they were looking for in a text and what criteria they would use to make their decision, Glenda identified 'reading age' and 'colour'. Her first criterion was, "Does it have a work program written for it?" When asked, "to what degree do you see the textbook as providing resources and knowledge content for yourself as well as the students?", the teachers replied that it was not so important for them as they had other resources to which they could refer, rather it would support teachers who had not taught science before. Anna also added that, "for topics that you didn't know much about you needed a good textbook that you could refer back to". The teachers also keenly felt that students and parents expected a textbook and that having a textbook presented a positive image about them as teachers and what they were teaching.

The teachers spent considerable time comparing the properties of the various science texts. Glenda favoured *Queensland Science* (Chandler, 2000) while Anna preferred *Jacaranda Science* (Ash, Lofts & Evergreen, 1999). Anna liked the interactive nature of *Jacaranda Science* and the many opportunities for student involvement in its science activities. Glenda felt that *Queensland Science* was comprehensive enough for non-specific science teachers and new teachers as it offered detailed explanations of science concepts. It became evident that there was a difference in beliefs between Glenda and Anna concerning the qualities of a good text. Both were looking for a text that reflected their pedagogical values; Glenda was looking for substantial content and explanations, and Anna was looking for many and varied activities that actively involved students in the learning.

The choice between the two textbooks generated considerable debate. The teachers decided to survey students for their preference. A simple survey of

student textbook preference was carried out. Although the final outcome of the survey was an even preference for both textbooks, the process revealed that both teachers and students appeared to value content quantity over content quality, justifying one textbook over the other by pointing out that one had more or lengthier explanations than the other and this made it better. Neither group probed the explanations provided in the science textbooks, rather content quality was based on the length of explanations and whether explanations were supported by images, diagrams or cartoon depictions. The former were more highly valued than the latter. Initial impressions suggest that students were divided in their choice of textbook according to their academic achievement. It appeared as though the high achievers chose *Queensland Science* citing reasons of more in-depth explanations and the non-academic group gravitated towards *Jacaranda Science*. Like the initial group of teachers, the students surveyed appeared to choose the text according to what they wanted it to fulfil, academic success or interest and fun. The 'academic success' group mostly chose *Queensland Science* and the 'interest and fun' group mostly chose *Jacaranda Science*. Both teachers and students saw the choice of a new textbook as a critical one that would directly influence the quality of the science education delivered and received. A likely interpretation is that textbook choice reflected the teachers' and students' respective images of science and what counts as knowledge, and their teaching and learning beliefs.

During a lengthy discussion between the teachers over the value and merits of a 'good' textbook, the pedagogical value, behaviour management aid, and status value of a text were all raised as important reasons for having a science textbook. It became apparent that these teachers saw a 'good' text as functioning almost as a surrogate teacher. Comments such as, "if you're away you can leave work from the text" and "if they're not behaving you can say, right open your books and do such and such" lend support to this idea.

TEACHER PLANNING

Despite assertions by the teachers that the textbook should not drive the science program, subsequent planning indicated otherwise. The scope and sequence were derived from a combination of the old science program and the new textbook. The textbook chapters became surrogate unit plans and guides for pedagogy (Sanchez & Valcàrcel, 1999). Glenda asserted that, "the textbook has to be not only a student reference but the main resource for the lesson".

Anna initially began planning from the science textbook, but became disillusioned with it when it became obvious to her that the outcomes the textbook claimed to be addressing were inaccurate. She then focused on the syllabus outcomes and what they meant in terms of student learning and how she might be able to assess learning in ways that motivated the

students. Anna conceived the idea of a terrarium where the students could investigate, design, build, and study, their own terrarium. Assessment was based on the students maintaining a logbook in which they recorded their initial design ideas and reasons for their various terrarium components, and daily observations along with explanations of what was happening and predictions for the future. Anna had resisted the focus on textbooks, and developed her own inquiry unit. Anna had willingly embarked upon writing inquiry units of work based on curriculum outcomes, and developed assessment that used open-ended tasks. In contrast, Glenda, the department head, focused on the content of each unit and designing content-based assessment. Glenda's content and pedagogy choices came from the science textbook and science lessons closely followed the textbook presentation. The contrasting approaches of these teachers became an underlying tension during the planning and implementation.

ASSESSING UNDERSTANDING WITH OUTCOMES

Anna was attempting to move to assessment practices based on demonstration of what students know and can do, but was constrained by existing assessment structures in the school. Anna's task was open-ended and allowed students to demonstrate their level of understanding. She had aimed to report in terms of what students knew and could do rather than award marks for content recital. Spenceley (2000) advocates using open questions and investigations that provide students with opportunities to develop and demonstrate conceptual understandings of learning outcomes. This was not supported by Glenda and limited the change process. In Anna's case, there was not a resistance to change, however the structure of the school's assessment and reporting practices, which Glenda felt compelled to adhere to, were not congruent with the reform principles underpinning the new science syllabus. The school's reporting structures required grades and the planned assessment was changed towards the end of the unit to measure content knowledge. Once the assessment task changed to assessing the content in the science textbook and instrumental understanding, the teachers refocused their teaching on the textbook to ensure that they covered all the textbook chapters. The initial focus on relational understanding had been abandoned. Anna's attempt to move towards outcomes-based learning and assessment was constrained by the school's assessment and reporting practices.

TEACHER BELIEFS

Glenda and other teachers supporting her lead seem to have held a positivistic or naïve-realist view of science and scientific knowledge. They treated the science knowledge in the textbook as truth and absolute. The teachers chose a textbook and program that matched their conception of understanding and effective pedagogies for science (see Abd-El-Khalick & Lederman, 2000). Glenda gave considerable attention to the amount of

content and explanations associated with scientific concepts when choosing a science textbook. Glenda's learning goals were instrumental and content focussed, while Anna's advocacy of an open-ended inquiry shows a leaning towards relational understandings. Anna was looking for activities in the textbook that facilitated active student involvement in designing and testing ideas.

IDEAL VERSUS ACTUAL SCIENCE TEACHING

A gap emerged between Anna's planning intentions and implementation of the inquiry based unit. Anna initially maintained that covering the textbook chapter content was not her goal. However, as the unit progressed and the initial, open-ended assessment task was changed by Glenda to a closed, pencil-and-paper task assessing textbook content, Anna relegated the inquiry task to the last ten minutes of the lesson and focused on completion of all the exercises in the textbook.

Opportunities to link the students' investigations to the textbook content were overlooked by Anna and the other teachers. During a conversation, Anna mentioned that a discussion about the terrariums that were failing would have been beneficial for the students in terms of their understanding; however, this had not been possible due to the shortage of time. When this was discussed further Anna mentioned that they had four more chapters to cover. When asked if these four chapters were associated with the concepts involved in the terrarium project and provided background for the terrarium logbook, Anna indicated that they were. She further explained that due to the shortage of time the teachers had reduced one chapter to three homework sheets, "so it was covered". It appeared that trying to accommodate incongruent pedagogies had introduced teaching and learning tensions for Anna and for her students.

In response to an inquiry as to what provided direction for teaching in the classroom, Anna responded that the textbook provided direction rather than the outcomes. Glenda felt students needed to complete all the learning experiences in the textbook. A checklist approach where tasks (those in the textbook and other teacher worksheets) were ticked off was used rather than a focus on whether or not the student has demonstrated the outcome. The checklist created considerable tension between Glenda and Anna. The focus on completing all the textbook activities suggests that the textbook was used to determine the pathway by which student learning was structured, and therefore, was the pathway that would provide opportunities for students to demonstrate the outcomes. This suggestion concurs with findings by Sanchez and Valcárcel (1999) that 92% of teachers surveyed "used the students' textbook as their principal reference" (p.498) for short term planning decisions.

In response to an inquiry about the textbook they were using Anna replied,

> *The text we've got is pretty good. It has all the outcomes at the front of the chapter so I think you can make the assumption that the text chapter does cover those outcomes; without that it would be very difficult. The text still drives it rather than the outcomes, but it's early days yet and we're still coming to an understanding of it.*

Anna's perception of the worth of the text had changed from her initial disparaging view. This 'sea change' suggests that in the absence of any formal structured planning (e.g., science work program or unit plan), these teachers fell back on the textbook to supply their work program, and scope and sequence. In brief, the choice of textbook became crucial to the way science was implemented in the classroom.

FORMATIVE ASSESSMENT AND DIALOGUE

Motivating students and engaging the students in inquiry had limited success. Observations suggest that students were very excited about the opportunity to design and conduct their own investigations, however, more interactive dialogue (Friere, 1973) was needed to facilitate conceptual understanding. Neither planned formative assessment (Bell & Cowie, 1999), nor interactive group evaluations were eventually included in the unit's assessment. Black and Wiliam's (1998) claim that teachers have an impoverished understanding of formative assessment may apply.

DISCUSSION

TEXTBOOK RELIANCE

Despite early assertions by the teachers that the text would not drive the science program, subsequent discussions and actions indicated otherwise. It became obvious that the new textbook was the 'new' science program providing not only the scope and sequence, but also the unit and lesson plans for teaching. The teachers' belief that the textbook was always right and that knowledge resided in the textbook indicated a naïve realist position. These teachers chose a text they felt best represented 'all the science knowledge' they needed and saw their role in the classroom as transmitting this body of knowledge, hence the emphasis on covering all the textbook content.

The teachers and students in this research project viewed the textbook as their 'lifeline' and a significant determiner of what happens in the classroom. Both teachers and students saw the choice of textbook as a critical one that would directly influence the quality of the science education that was delivered and received. This is not problematic if the science textbook is chosen for rigorous science education reasons and those choosing the textbook are familiar with the science education reform agenda. However the findings of this research suggest that the teachers' eventual choice of text was for reasons that were not congruent with the

reform agenda initiatives underpinning the new science syllabus. The teachers looked to the textbook to supply appropriate content and pedagogies, in essence it was their pedagogical content knowledge. It is most likely that the eventual textbook choice reflected the teachers' image of science and science knowledge, and their teaching and learning beliefs. The teachers' preoccupation with textbook explanations of science concepts suggested they were operating from a positivist view of science and scientific knowledge.

Thus, rather than the teacher being in control of the design of the science experience in the classroom, selecting activities and experiences to suit the learning needs of their students, it appears that these science teachers may well have surrendered control over the shape and form of delivery of science units to textbook authors. The science content understanding, pedagogical approaches and philosophy of science of the textbook authors assumed significant importance in this school. Accordingly, the choice of textbook seems crucial to the manner in which science education is implemented at the classroom level in Junior secondary science in this school.

Once the assessment of the terrarium unit was changed from the open-ended task originally proposed to the closed task assessing factual recall, teachers felt compelled to cover all the content in the designated textbook chapters. This close relationship between teacher planning and implementation, and the science textbook, concurs with Weiss et al.'s (2003) finding that science lesson content, and sequence of topics, was significantly influenced by the textbook.

Students experience science through the teaching strategies chosen by the teacher and, therefore the teaching strategies used to implement the curriculum are important in shaping students' attitudes to science. The literature supports the view that the teaching strategies chosen by the teacher impact on the students' view of science. This study points to the science textbook as the most important tool in the teachers' planning. The choice of teaching strategies is determined by the learning experiences presented in the textbook and it follows, therefore, that the students' view of science is shaped by the science textbook chosen by teachers.

CONSTRAINTS TO REFORM CHANGES

A significant gap between teacher planning intentions and implementation occurred. Several factors challenged the teachers' ideal intentions to implement an inquiry and outcome-based unit of work; their beliefs about the nature of science and effective science teaching, their heavy reliance on a science textbook, and their own professional knowledge and confidence with open-ended assessment strategies.

The teachers' own beliefs about the nature of science and what is effective science teaching may have been inconsistent with the assumptions underpinning the new syllabus. The structure of the science syllabus

provides a guide for teachers in their preparation to teach. Levels within each topic strand outline a sequence that can facilitate the expansion of the students' conceptual framework at each level. In an outcomes framework, the process by which students learn science might be conceptualised as follows: Students use their existing knowledge or conceptual framework to make observations. They use their observations to formulate facts which are then used to construct meanings and explanations. These explanations form part of their scientific knowledge about the world around them. The implications for the teaching and learning process are that students need to be provided with opportunities to make observations, and make sense of them by constructing explanations. The accumulation of facts only will not lead to the conceptual knowledge required for scientific literacy.

Secondly, the teachers' heavy reliance on a textbook for planning and teaching may have contributed to the problem. If the textbook used by the teachers promotes instrumental learning of content rather than relational understanding of concepts then the teachers' main resource would be inconsistent with the syllabus. The science textbook is the principal resource used by science teachers when planning, guiding both scope and sequence, and learning experiences (Sanchez & Valcárcel, 1999). How teachers use the textbook influences the effectiveness of the science teaching (Ebenezer & Zoller, 1993; Speering & Rennie, 1996). Lack of time and expertise in planning science units often results in teachers' uncritical adoption of a textbook and the learning experiences within (Gallagher, 1991). This results in an emphasis on content memorization, transmissionist teaching styles and the presentation of science facts (Gallagher, 1991). The textbook plays a significant part in shaping the image of science portrayed to secondary science students through the content and learning experiences it contains (Milne, 1998). An inaccurate image of science may be portrayed to students by the uncritical use of the science textbook.

Thirdly, the teacher's own professional knowledge of, or level of confidence with teaching and assessment strategies that support an outcomes-based science syllabus may be deficient. Teachers themselves require a deep conceptual understanding of science and familiarity with open-ended forms of assessment. It is worth considering whether the change process needed to begin with Glenda, rather than with Anna, in order for it to have been successful. A lead or mentor teacher may have had more success countering the textbook driven curriculum.

CONCLUSION

There is an urgent need to ensure a strong link exists between science education policy and what is presented in science textbooks. If, as this study indicates, the quality of the science education delivered in lower secondary schools relies heavily on the science textbook chosen by

teachers, then it is imperative that the writers and publishers of science textbooks have an informed understanding of current science education principles so that the two are congruent. Whilst the science textbook appears to be a pervasive influence on classroom science, it is the way in which science teachers use the science textbook that lies at the crux of science reform. In order for teachers to make an informed choice about which science textbook and how they will use the science textbook, it is recommended that a sound understanding of the nature and construction of scientific knowledge is essential. Professional development programs encouraging teachers to examine their nature of science beliefs are urgently needed. The dependent relationship between science teachers and the textbook needs further exploration to identify ways teachers can be encouraged to become more critical of the textbook in their planning. School reporting structures also need to change to accord with the pedagogies and assessment practices of inquiry based units of science. In short, there is a critical need to ensure that the purposes of science education are congruent with the policy statements, programs (including textbooks and other resource materials), practices of teachers and experiences of students. Closing the gap between the ideal and actual science teaching in lower secondary science is a pressing need.

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