Scientific literacy is generally valued and acknowledged among educators as a desirable student learning outcome. However, what scientific literacy really means in terms of classroom practice and student learning is debatable due to the inherent complexity of the term and varying expectations of what it means for learning outcomes. To date, the teacher voice has been noticeably absent from this debate even though the very nature of teacher expertise lies at the heart of the processes which shape students’ scientific literacy. The chapters that comprise this book tap into the expertise of a group of primary teachers from Our Lady of Good Counsel (OLGC), a primary school that chose to actively engage in teaching for scientific literacy. By analyzing the insights and thinking that emerged as they attempted to unravel some of the pedagogical complexities associated with constructing an understanding of scientific literacy in their own classrooms, these teachers demonstrate the professional knowledge and skill inherent in the expertise of teaching and learning science in a primary classroom. The chapters in this book illustrate the processes and structures that were created at OGLC to provide the conditions that allowed these teachers to explore and build on the range of ideas that informed their approach to teaching for scientific literacy. This book is a compelling example of how a whole school approach to scientific literacy can make a difference for students’ learning of science and offer a concrete example of the development of professional knowledge and practice of teachers.
Scientific Literacy Under the Microscope
Professional Learning
Volume 11

Series editor:

J. John Loughran, Monash University, Clayton, Australia

Editorial board:
Renee Clift - University of Arizona, USA
Ruth Kane - Ottawa University, Canada
Mieke Lunenberg - Free University, The Netherlands
Anthony Clarke - University of British Columbia, Canada
Donald Freeman - University of Michigan, USA
MOK, Mo Ching Magdalena - Hong Kong Institute of Education, Hong Kong
Max van Manen - University of Alberta, Canada

Rationale:

This series purposely sets out to illustrate a range of approaches to Professional Learning and to highlight the importance of teachers and teacher educators taking the lead in reframing and responding to their practice, not just to illuminate the field but to foster genuine educational change.

Audience:

The series will be of interest to teachers, teacher educators and others in fields of professional practice as the context and practice of the pedagogue is the prime focus of such work. Professional Learning is closely aligned to much of the ideas associated with reflective practice, action research, practitioner inquiry and teacher as researcher.
Scientific Literacy Under the Microscope

A Whole School Approach to Science Teaching and Learning

Edited by

John Loughran, Kathy Smith and Amanda Berry

Monash University, Australia
TABLE OF CONTENTS

Acknowledgements ........................................................................................................ vii

Section 1: Preparing for Scientific Literacy

1. Scientific Literacy: A Symbol for Change......................................................... 3
   Simon Lindsay

2. Paving the Way for Scientific Literacy .......................................................... 17
   Brian Grace

3. Learning from Teacher Thinking: An Insight into the Pedagogical
   Complexities of Scientific Literacy ................................................................. 25
   Kathy Smith

Section 2: Teaching for Scientific Literacy

4. Wearing the Double L Plates: Lead Learner................................................. 39
   Cathy Dimitrakopoulos

5. You Don’t Have to Have All the Answers ..................................................... 47
   Mary Howard

6. Action that Matters....................................................................................... 59
   Tracy Adams

7. ‘Y’ Scientific Literacy? .............................................................................. 67
   Michelle Verna

8. Layering: A Personal Journey ..................................................................... 75
   Margaret Hose

9. It’s Multi Domain: But Where’s the Scientific Literacy? ............................ 81
   Anthony Walsh

10. Busting the Myths about Science Teaching .............................................. 93
    Stephen Walsh

11. Speaking about Scientific Literacy ............................................................ 101
    Ann France
TABLE OF CONTENTS

Section 3: Reviewing Scientific Literacy

12. You Don’t Know What You Don’t Know ...................................................... 113
   Joanna Kakos

13. Unboxing My Science Teaching: A Personal Scientific
    Literacy Journey ............................................................................................. 119
   Rosemary Cussen

14. Why Does Scientific Literacy Matter in Primary Schools?: Reflections
    on the OLGC Experience ................................................................................ 127
   Pernilla Nilsson

15. Responding to the Challenge of Scientific Literacy: A Whole School
    Approach to Scientific Literacy ...................................................................... 139
   John Loughran

Index ....................................................................................................................... 149
ACKNOWLEDGEMENTS

The editors and authors of this book are most grateful to the support from the Catholic Education Office Melbourne (CEOM), the Faculty of Education, Monash University, the Principal Gilbert Keisler and the staff of Our Lady of Good Counsel (OLGC) Primary School, Deependene.

The research that underpins this book was made possible through an Australian Research Council Linkage Grant.
SECTION 1:
PREPARING FOR SCIENTIFIC LITERACY
SIMON LINDSAY

1. SCIENTIFIC LITERACY

A Symbol for Change

What kind of science education meets the needs of the minority of students who will go on to become scientists at the expense of the much larger numbers who will not? (Dillon, 2009, p. 3)

PART 1: THE NEED FOR SCIENTIFIC LITERACY

It is often said the only place you see Bunsen burners is in schools. The only place you write up a prac. report is in schools. The only place you wear white lab coats, memorise the periodic table, mix bicarb and vinegar, or make a volcano, is in schools; just in case you ever need to - which most of us don’t. Somehow we’ve remained stuck representing to students an outmoded, irrelevant, and possibly inaccurate perspective of science, given that “society itself has moved on from the “industrial” era through the “knowledge” era, and arguably into an era of design and innovation” (McCann, 2006, p. 40).

Science is a human construct and a function of societal needs. It makes sense that the nature of science changes as these needs vary over time and place. The role of science can be seen to be different in Afghanistan to what it is in Antarctica, different in the Babylonian times than the Renaissance, different in India to what it is at Our Lady of Good Counsel (OLGC), Deepdene Victoria. Science hasn’t always looked like “1960s Victoria”, and it probably won’t look that way in the future.

This revelation that the role and purpose of science can and does change is confronting. The implication for us as educators suggests that we also need to change. It is relatively easy to argue that there is currently a mismatch between the type of science perceived by society, and the type which is currently perpetuated in schools and by policy makers in science education. The change to a new conception and practice of science education is ostensibly slow.

Maybe the reluctance to change stems from the fact that this is the way we were taught science at school, and therefore it is all we really know. Therefore, we invariably hang on to the familiar and known - to the clean clinical lines, the blue lab desks, the Bunsen burners, the text books, the repetition, the memorisation, the order, the power. Maybe it is because the industrial era of science was in many ways so successful, marked by great scientific advancements in transport, electricity, medicine and communication. Thus arguments to suggest a deviation from this are considered by some to be almost sacrilege.

© 2011 Sense Publishers. All rights reserved.
Maybe it is because the dominant mantra of industrial-era science of reason and rationality and objectivity is just too difficult to challenge. Moves towards a more social conception of science may be seen as “soft” by some scientists and science educators - not “rigorous” nor “well founded in the discipline” or “not enough to prepare one for university”. Comments such as these still ring loudly and persuasively in current curriculum debate at the national level further illustrating the divide which exists in Australian science education.

The phrase Scientific Literacy marks that divide well. Notwithstanding all the debate over definitions of scientific literacy, one could argue that at the very least, scientific literacy describes the attempt to move towards a more socially useful conception of science education. Roberts (2007a) makes a helpful distinction between two ways of looking at the aims and purposes of science education in his chapter on scientific literacy in the Handbook of Research on Science Education. Roberts notes that:

... that there appear to be two schools of thought that characterize all of this definitional activity, based on two ‘visions’ of the appropriate basis for generating conceptions of scientific literacy appropriate for school science. They are called, simply, Vision I and Vision II. On one hand, Vision I looks inward at science itself – its products such as laws and theories, and its processes such as hypothesizing and experimenting. According to this vision, goals for school science should be based on the knowledge and skill sets that enable students to approach and think about situations as a professional scientist would. Vision II, on the other hand, looks outward at situations in which science has a role, such as decision-making about socio-scientific issues. In Vision II thinking, goals for school science should be based on the knowledge and skill sets that enable students to approach and think about situations as a citizen well informed about science would. (Roberts, 2007b, p. 9)

These visions are underpinned by different values and, at their most extreme, reflect the competing interests that have and continue to influence the school curriculum. At one extreme, there are those whose major preoccupation is the place of scientific content in the curriculum. At the other extreme are those who argue that science education should encourage students to challenge the assumptions underpinning science as a cultural activity (see, for example, Roth & Barton, 2004). The job of policy makers and teachers alike involves reconciling these conflicting visions even though there may be pressure to promote one vision over another (Blades, 1997; Fensham, 1998).

The Rise of Scientific Literacy: The Search for Something Different

Derek Hodson stated as early as 2003 in his paper Time for action: science education for an alternative future “it is time to take action on the school science curriculum because it no longer meets the needs, interests and aspirations of young citizens” (p. 643). Levels of student engagement with science, as assessed through the Programme for International Student Assessment (PISA), suggest that Australian students are disaffected with traditional approaches to science teaching (McGaw, 2010).
Table 1.1. PISA 2006 engaging with science rankings (McGaw, 2010)

<table>
<thead>
<tr>
<th>Aspect of engagement</th>
<th>Level of engagement/Rank among 57 countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>General value of science</td>
<td>41st</td>
</tr>
<tr>
<td>Personal value of science</td>
<td>37th</td>
</tr>
<tr>
<td>General interest in science</td>
<td>54th</td>
</tr>
<tr>
<td>Enjoyment of science</td>
<td>45th</td>
</tr>
<tr>
<td>Self concept in science</td>
<td>43rd</td>
</tr>
<tr>
<td>Future-oriented motivation to learn</td>
<td>42nd</td>
</tr>
<tr>
<td>Involvement in science-related activities</td>
<td>53rd</td>
</tr>
</tbody>
</table>

PISA, the worldwide evaluation of 15-year-old school pupils’ scholastic performance, performed first in 2000 and repeated every three years, is coordinated by the Organization for Economic Co-operation and Development (OECD), with a view to improving educational policies and outcomes. In 2006, the PISA study had a focus on assessing scientific literacy, targeting both student understandings and levels of student engagement with science. The data is damning with regard to the levels of engagement of Australian students with science (see Table 1.1).

As can be seen from Table 1.1 above, Australia is 54th out of 57 countries with respect to “General interest in science” - meaning only three countries amongst a great proportion of the world have less interest in science than do our students. In my eyes, there is no more urgent argument for change than is clear through this statistic. This outcome related to interest in science is often overlooked in the public announcements of PISA results – we are in fact 3rd or 4th out of 57 when it comes to understanding of science (McGaw, 2010). But a disturbing conclusion we could reasonably draw from these statistics is that while our students may pass the science tests at school, they will be the fastest to drop science from their mindset as soon as possible once they leave school. For a system such as the Catholic Education Office Melbourne (CEOM) which values life-long interest, interaction and engagement in science for all people, as hopefully does the Nation, this has serious implications for the future health and well-being of our individuals and society collectively.

Two main elements appear to be contributing to a renewed need to push for change in science education. Firstly, society is faced with a pressing set of socio-environmental issues including climate change, drought, the energy crisis, obesity, biodiversity, stem-cell research, cloning, nanotechnology, carcinogens and cancer - the list goes on. Secondly, we are awash with information about these issues in the media – on the internet, in the news, on forums, in advertising, mobile phones, social networks, satellite TV etc. - the impact of which is continuous presentation of (science related) information to individuals.

The combination of these two factors means that students need a new set of capabilities to critically engage with science – and it could be argued that these capabilities are different form that gained by previous generations in their years at
school. It also highlights the need for all citizens to be able to engage with science, as opposed to leaving the remedies only in the hands of scientists. There is an argument to suggest that a blinkered view of science and its potential to solve everything has partly caused the environmental predicaments we now face. The distinction between science issues and social issues has become blurred, and the effectiveness of solving social problems with scientific fixes is a cause of long-held discontent. And so the hypothesis goes that if all citizens had capabilities to engage with these socio-scientific issues, then individuals and their societies would be in a better position to solve them in a more informed and effective way.

There have been many attempts over the last 50 years to conceptualise a more socially-oriented version of science education. Such attempts have been codified under different names or headings such as, Science Technology Society (STS), Science Technology Society Environment (STSE), Science for All, Science for Public Understanding, Citizen Science etc. Most, if not all of these conceptions move in some way towards the Vision 2 approach which Roberts described. The term scientific literacy came to prominence as early as the 1950s perhaps as a way of encapsulating these ideas into a new movement in science education.

Since the first use of scientific literacy, science educators and policy makers have gradually reconceptualised the term to such an extent that one author has remarked that it is ‘ill-defined and diffuse’ (Laugksch, 2000, p. 71). Yet despite this lack of clarity, scientific literacy is now the focus of curriculum standards in many countries and is at the heart of international comparisons of student attainment (and thus of education systems) including the OECD’s PISA. Indeed, the term has become so common that McEneaney (2003) has described it as having ‘worldwide cachet’.

It may be that the term scientific literacy strikes a chord for many, not because of the clarity or instruction that it provides, but for the simple reason that it coins a phrase for change in science teaching and learning. I believe that the most useful aspect of scientific literacy might be as a symbol for change where change in science education has been notoriously hard to affect. To me it is a symbol for a more human-centred, useful, contemporary notion of science education. It has the potential to act as a banner under which teachers and systems alike can move forward in science - providing a justification, a language, and perhaps direction, for new science teaching and learning. In my work with teachers across schools, it seems that many teachers intuitively feel that the idea of scientific literacy, whatever the specific definition, responds better to the type of 21st century society in which they live, than that which is currently taught as science education in most primary and secondary schools.

It would be difficult to argue with McEneaney’s (2003) claim that scientific literacy now has a worldwide cachet. Many countries around are actively trialling different courses and programs under the banner of scientific literacy. The United Kingdom has introduced the Science in the 21st Century program, which involves new courses for secondary school students based around scientific literacy. In the US, Project 2061 has produced the *Benchmarks for Scientific Literacy* and *Atlas of Scientific Literacy* among their reform efforts in science education. In Canada the *STEPWISE* program (Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments) has been trialled, in the Netherlands the
Algemene Natuurwetenschappen, the Sinus program in Germany, and scientific literacy reforms are also afoot in Turkey and South Africa amongst many others.

Just as different countries make decisions about the types of programs and outcomes they want for their students from science education, so too do the different education jurisdictions within countries. Not all education jurisdictions within a geographic region value the same outcomes – indeed, Government, Independent and Catholic systems have different values and beliefs about the nature of quality education for their students, and subsequently about the function and purpose of science education towards this end.

Distinctive Nature of Catholic Schooling

In the CEOM Strategy Plan for the Archdiocese of Melbourne 2006–2010, One Body: Many Parts, one of the four stated vision outcomes for students is the capacity for ‘Active Citizenship’ - to cultivate students who are “empowered to contribute to the common good of society” (p. 1). Within One Body: Many Parts, the CEOM’s Learning Centred Schools, A Sacred Landscape articulates a Learning and Teaching framework for the Archdiocese of Melbourne. It acknowledges that “the rate of tech and social change requires new ways of learning that equip students to be lifelong learners and persons better adapted to the challenges of a rapidly changing world” (p. 6).

A Sacred Landscape describes the distinctive nature of Catholic schooling, in particular that a Catholic school is a “school for the human person and persons”. Learning experiences are developed “as a way of creating meaning in life, of developing human potential, and of liberating and empowering individuals to be responsible for their own lives and contribute to the Australian society” (p. 4). It also states that our role as teachers and as a system is to ensure that our students “become free and responsible … capable of engaging with the Australian culture and society … empowered to enrich this world with direction, meaning, purpose and hope” (p. 4).

These values regarding the nature of learning for our students must in turn shape the way we view and practice science education. More simply, to be true to our values, we must do what we believe; we must practice what we preach.

CEOM Vision for Science Learning

In 2008 a CEOM Science Reference Group attempted to elicit the values of teachers, principals, policy makers and academics in order to formulate explicitly what the system valued from a science education. As a result, the CEOM established a vision for learning in science in the 21st Century. The vision articulates ten desired outcomes for students as a consequence of Catholic science education. A vision centred around the desired outcomes of science education followed on from a recommendation based on commissioned research and reference points (Millar, 2008; Dillon, 2009; Loughran, 2009; CEOM, 2010) within science education so that education jurisdictions could clearly define the nature of outcomes for their own students based upon the values of the system itself. The following Table (1.2) states these outcomes.
Table 1.2. Outcomes for learning in science in 21st century

The outcomes desired for students from a science education in the Archdiocese of Melbourne are, that all students

1. Are bold and confident participants in a constantly changing 21st century world
Students possess knowledge and skills in science which assists in creating resilience to frequent change and emboldens individuals to take action where appropriate. Students are open to change and take measured risks with creativity, open-mindedness, and independent thinking.

2. Appreciate science as a way of knowing about the world
Students appreciate and use science as a way of learning acting, knowing and thinking. They can compare science as a way of knowing with other forms of knowing including religion, history, art etc, and recognize the value of different cultural and indigenous perspectives of knowing about the world. They possess the skills to investigate interesting questions about their world.

3. Possess a sense of awe and fascination about the world
Students possess a continuing sense of awe and fascination about the mystery and beauty of the world in which they live. Students have an appreciation of the complexity of the world around them, and have an ongoing interest in and curiosity about the world and its scientific makeup.

4. Understand the impact of science on society
Students have an appreciation and understanding of the impact of science and technology on everyday life. This includes the incredibly positive outcomes for society which science engenders, but also the negative. Students have a sensitivity to, and awareness of, the place and role of science in different cultural contexts.

5. Are savvy consumers of science
Students are critical of, and sceptical about science and, the ways it is communicated, such as in the media. Students are able to, and have the confidence to, determine what they need to know in science, critically assess information they encounter and critically evaluate how trustworthy is this information. They are able to determine how they will access accurate information and make informed decisions about what will be useful to them in future decision making. They can communicate their understandings, ideas, and beliefs about science to others in meaningful ways.

6. Understand the nature of science and science concepts that are relevant and useful to their lives
Students have an appreciation of the changing nature of science and that its basis of science knowledge, science inquiry and science as a human endeavour will shift, grow and or change over time. With such changes, students will need to constantly reassess how their basic understanding of science concepts actually influences their changing world.

7. Accept a responsibility towards the natural environment
Students accept a care for God’s creation. Students understand that their decisions and actions have consequences for the environment, both positive and negative.
Table 1.2. (Continued)

8. Understand science as being value-laden
Students recognize that science is not wholly objective, but instead a human construction to explain our natural world and therefore laden with the values which different people bring to it. Accepted scientific views are a result of scientists reaching a consensus about science explanations. Similarly, students need to participate in informed debate about science explanations and their associated moral and ethical issues associated. Students need to appreciate why moral and ethical considerations are taken into account in such decision-making.

9. Engage with science as accessible and do-able
Students are intrinsically motivated to take on the challenges of science. They have an appreciation of science as do-able, achievable, and accessible to them. They have the skills to investigate interesting questions about their world.

10. See the potential for science to contribute to the common good
Students see themselves as global citizens, and the potential role that science plays in contributing to the common good. Students are empowered to enrich the world with direction, meaning, purpose and hope.

Science Education as a Matter of Value

Choice of curriculum content, depth of treatment, and emphasis, are matters of value; they cannot be resolved by empirical data. Once we have agreed on them, of course, we can then seek empirical evidence about which way (or ways) of teaching them are most effective. (Millar, 2008, p. 1)

In the messiness of arguing over definitions of scientific literacy, (a situation which has arguably hampered progress in science education), it may be important to note that the attempt to define scientific literacy is largely a philosophical argument; not scientific or educational. Questions such as: ‘What outcomes do we want for our students in our communities?’; and, ‘For whom are we teaching science?’ are matters of value, not science. Answers to these questions are largely contextualised, and thus should be inherently different from each other. There is no expectation then that different groups, bodies, or organisations around the world should reach consensus on the definition of scientific literacy, as answers to these questions should differ according to the values of the organisations themselves. However, what seems to be a common thread among all definitions of scientific literacy is a focus on the capacity to use science within, or for, some sort of beneficial societal purpose. So, notwithstanding the contextual nature of scientific literacy, it seems that whichever way one defines it, scientific literacy invariably means more than just learning the science content.

Science for All

One of the prime functions of science in the industrial era was to produce new knowledge, and subsequently for science education to produce the scientists who would be the driving force of that knowledge production. After World War II, the need to
reindustrialise took focus forcing school curricular to adjust in order to meet the need for the increasing number of science graduates (Murdoch, 2006). Millar suggested that this focus has not changed - that most school science still looks as though it has been designed primarily to begin the training of the next generation of research scientists.

Dillon highlighted a concern in that science education could be seen as more often than not benefiting the minority of students who go on to become scientists at the cost of those who do not. Further to this, Millar suggested that science educators were faced with confronting a value propositions based on the question “Who you are teaching science for?” (Millar, 2008). If science education is for ALL students, then the associated type of curriculum and pedagogy should be markedly different from that associated with teaching science explicitly for those who become scientists.

The CEOM has positioned itself clearly in favour of a science education for all students. If the Archdiocese of Melbourne wants a science education for all students, whereby students will “see the potential for science to contribute to the common good”, “engage with science as accessible and doable” and who can think critically about scientific issues as well as make good decisions for themselves and society, then the curriculum and pedagogy of teachers must change in order for this be evident in practice. But how does a system go about supporting teachers with change of this kind on a large scale?

PART 2: THE NATURE OF SYSTEM SUPPORT FOR SCIENTIFIC LITERACY

Focusing on School Factors in Professional Learning

Large-scale improvement in science learning and teaching across a sector of 350 schools is a difficult challenge. Historically, most efforts at this have involved large, “broad-brush”, automated professional development (PD) programs which target as many teachers as possible to produce an overall “mass effect” on the sector. This approach might make sense at first sight; after all, there have been significant studies which find that teacher quality is the most important factor in student achievement. However, while the mass PD approach to sector-wide improvement may work on occasions in subjects such as literacy and numeracy, there are some fundamental differences in the way science education is enacted in a school (particularly at a primary level) which have the potential to negate the impact of teacher quality on improvement in science.

Firstly, science is not as compulsory within the curriculum as mathematics and literacy. There are no NAPLAN (National Assessment Program – Literacy and Numeracy) tests and little overt pressure from parents or governments for increased science in schools. Science is often seen as optional in many primary schools, or at the very most, given passing attention within the curriculum. Secondly, formal leadership within a school is not often a proactive enabler of science within the school. The message that this invariably sends to teachers is that science is not important and not worth professional time and energy. It may also make endeavours to improve science through partnerships or projects more difficult to initiate if teachers know
there will be little support when it comes to implementation. The nature of leadership support for science also tends to dictate how science is incorporated into the planning process and subsequently into the curriculum. It could be argued that it is difficult to show quality teaching in science when time and emphasis within curriculum planning is not supported.

The type and amount of resourcing within a school also impacts the abilities of teachers to demonstrate their teacher quality in science. Poorly resourced school efforts in science dampen teacher motivation for improvement. A lack of a culture of prominent science teaching, and associated poor profile and standing of science within a school can also inhibit the ability of teachers to operate at their genuine teacher standards. The combined affect of these factors means that sector attempts to improve teacher quality in science may have a reduced impact if they don’t address these other whole-school factors. From a personal perspective through observation across many schools, I have seen teachers who have undergone what I would have argued was high quality professional learning, but certain school factors have persisted that have negated the anticipated outcomes from such professional learning experiences.

The upshot of this is that individual school factors need to be addressed equally, if not more, than teacher quality issues in science. If science is not on the school agenda, teacher quality in science will generally be quashed. These observations have prompted the CEOM to rethink approaches to scaling up professional learning for sector-wide improvement in science, particularly when considering the type of professional learning support required to genuinely enable the development of scientific literacy.

**Taking a Different System Approach**

Scientific literacy is a diffuse, complex idea open to wide interpretation. It has become increasingly clear to me that change in science education towards a scientific literacy approach is not going to be solved by a top-down PD program rolled-out for the masses. The development of scientific literacy in the ways I have outlined above requires deliberate and careful consideration on behalf of teachers, and as such, dedicated time and structures for reflection and spaces to experiment and play with ideas. In attempting to respond to the school factors which impact the effectiveness of teacher quality programs in schools, one recent action has been to approach the school as an entity in itself - a whole learning community. In so doing there is acknowledgement of the interrelatedness of all elements of schooling and the often fickle balance which resides within a dynamic and ever-changing system.

By paying attention to issues associated with the nature of teacher change – in particular the need for it to be supported of over long periods of time - the CEOM in collaboration with Monash University developed the Science Teaching and Learning (STaL) program. STaL was a five day, year-long professional learning program that specifically targeted learning and teaching in science. Our Lady of Good Counsel (OLGC) Deepdene had the foresight to send four teachers to the 2006 program, and multiple teachers to all programs since. STaL became the professional learning
which underpinned OLGC’s work in scientific literacy. The STaL program had built-in time for reflection and discussion. A whole day was devoted at the end of the program for a process of reflection and writing in the form of cases (Shulman, 1992). Between-school visits were facilitated to maintain and develop participants’ thinking. But above and beyond the content that was delivered, the program established the core values of teacher-led change, active teacher reflection, treating teachers as professionals, and a focus on relationships – all of which were to underpin all subsequent professional learning in science at the school.

OLGC’s continued involvement in STaL combined with extra support from the CEOM and the Monash team created time for OLGC to implement and trial ideas at a whole-school level. Together, the CEOM and the Monash team supported the school to trial a whole-school, multi-domain approach to planning which built notions of scientific literacy, as well as time to trial and practise planned units in the classroom.

Allowing time for OLGC to think and talk and trial was one of the most important aspects of successful change at OLGC. In what could be an important lesson for other policy makers, interestingly, it took over four years before we saw outcomes of the kind usually sought by bureaucracies as measures of success. Allowing real time for deep and sustained change is rare among education bureaucracies because it goes against most bureaucratic system imperatives which insist on overt outcomes in short time periods, frequently in annual allotments. In the face of few major milestones and little physical change in teacher practice as viewed from the outside, those working closely with the school, which importantly included members of the CEOM and Monash, saw at close hand changes in teacher thinking, teacher language, teacher planning and eventually significant change in classroom practice.

Another important element of the nature of system support provided to OLGC was to allow teachers take charge of their own professional learning which led to a greater appreciation for, and value of, their professional knowledge. There was a deliberate “light-touch” approach from a system point of view and no pressure in terms of timeframes for success was imposed on the school. Instead surrounding the school with good people and funding to support autonomy in decision making, development directions and expected actions were essential so that the school maintained professional responsibility in driving its own change.

Creating conditions for teacher professional learning was crucial and that is difficult to achieve if teachers are not respected as professionals. During the STaL program teachers were supplied with overnight accommodation in first-rate hotels complete with dinner, breakfast, and social drinks in just the same was as occurs in most other professions. During the writing of this book, teachers were through writing workshops and dinners as well as weekend writing retreats in productive locations. In valuing and respecting teachers in this way the values of the system itself (CEOM) became explicit in terms of valuing individuals, valuing teachers as professionals, and respecting teachers as innovators and knowledge builders.

Another important element of system support for this project was the association with a University, more specifically, a University with a history of supporting teacher-led change (a University that cared about teachers and valued relationships enough
to seek to build their trust). In essence, co-operation and collaboration between an educational system and a University whose values about schooling and operation was an important feature of the overall process. The Monash team provided the academic rigour and profile that allowed a relationship to develop that focussed the nature of interactions rather than measureable, short term outcomes.

A final and vital element of system support for OLGC was in the provision of explicit structures for reflection. The use of a ‘critical friend’ within the project provided teachers with an ongoing stimulus for thinking differently about scientific literacy. The importance of a critical friend cannot be understated. It allowed teachers to develop their own understandings of that which matters in science education. The use of cases as a way of encouraging teachers to reflect on their practice also provided a structure for thinking differently about science teaching and learning. The writing of these cases by teachers at OLGC has been showcased through the subsequent STaL publications (see, Berry & Keast, 2009, 2010; Loughran & Berry, 2006, 2007, 2008).

Over time, the focus on the aforementioned whole-school factors bore fruit. Leadership support for science was strong and active, profile for science was high and embedded in everyday school-life, the standing of teachers in science was raised through their publications, an innovative centre for scientific literacy was built, and a whole-school planning approach around scientific literacy for students was established. Out of this mix came teacher-led, whole-school change, where teachers had ownership of their ideas, control over its direction, and clarity about what scientific literacy meant for them.

Indirect Scaling

As the expertise of teachers at OLGC increased and the school became advanced in its thinking and practice, the CEOM thought about how to scale up the model for other schools. In line with historical education efforts at scaling up, it would be a natural extension for the school to become a lighthouse school for others in the Diocese. But it became apparent that the inherent differences between schools, together with the contextual nature of scientific literacy, would make it difficult to simply transpose, or even suggest, the OLGC model to other schools.

So OLGC was left to grow and develop in its own time. Interestingly, what we are beginning to see is a more natural extension of expertise and knowledge out to other schools as teachers develop, grow and move to positions in other schools. The Principal who oversaw the start of the project moved to a nearby school and is embarking on a similar program of scientific literacy with his staff in a new context. The Deputy Principal recently gained his first principalship at another school and is taking his learnings to his new school. The mathematics coordinator has become the Deputy Principal at another school, the curriculum coordinator is working across a number of schools, staff have contributed to state, national and international conferences related to scientific literacy, and have published a whole school set of cases about science teaching and learning (Smith, 2007), a number of staff attended leadership programs in science education and produced video resources for other
schools, not to mention the production of this book for other schools, and so on. The outcomes are impressive indeed.

Thus instead of a system pushing a model for scientific literacy on to other schools, there are now numerous others embarking on change initiated by the schools themselves based on an informed position and created in response to their own context. A form of indirect scaling has occurred without system mandates that appear to have resulted in an effective spread of ideas and expertise.

CONCLUSION

The chapters that follow represent an emerging map of how, when and why participating teachers at OLGC found scientific literacy in their own way. Throughout each of the chapters there is a thread that ties together changes in teacher thinking, curriculum planning, classroom practice, and student learning. These learning features portrayed through these chapters are reflective of the sorts of outcomes commonly sought by educationalists in relation to notions of active participation in the 21st century. The chapters are also reflective of the values that the teachers, school and system have come to articulate and proudly display.

The experiences written about in this book indicate that these teachers found the idea of scientific literacy to be useful. But perhaps more importantly, it is clear that the phrase scientific literacy itself has actually provided a symbol for change and a banner under which both school and system have learnt to operate differently.

REFERENCES


*Simon Lindsay is a Senior Project Officer for Science, Innovation and Research at the Catholic Education Office Melbourne (CEOM).*
2. PAVING THE WAY FOR SCIENTIFIC LITERACY

OLGC IS A LEARNING COMMUNITY

Our Lady of Good Counsel (OLGC) is a learning community focused on developing the learning outcomes for each individual learner. Every staff member lives this through the school’s vision statement of “Nurturing Mind Body and Soul”.

I need to say from the outset in reflecting on the work that has gone into our Scientific Literacy project that, at OLGC, it was an expectation, not an option that each staff member was involved in professional learning that would not only develop them as an educator, but also improve their students’ learning outcomes. That involvement in professional learning was an expectation that was always clearly expressed to potential staff at the interview stage by both the principal and myself (Deputy Principal). For some potential staff that expectation was too much and so they shied away from accepting a position at OLGC. However, for others the expectation was in full accord with that which they were seeking in their teaching career and therefore did not hesitate to accept a position at OLGC when it was offered. Clearly then, my view of the OLGC staff is one imbued with admiration for their willingness to continually develop themselves professionally.

With such a group of dedicated professional staff members eager to improve student learning outcomes, OLGC was involved in many projects. These projects ranged from the Enhancing Performance and Development Culture project through to the STaL project (which was run in conjunction with Monash University and the Catholic Education Office Melbourne).

In my role as Deputy Principal and more recently as Acting Principal I worked closely with both the leadership team (Principal, Deputy Principal, Head of Curriculum, Head of Student Services, Head of Junior School and Head of Senior school) and the staff, to ensure that whatever professional learning was undertaken would directly affect student outcomes. The question “How will this professional learning impact positively on student outcomes?”, was a question that the staff or leadership team knew they would be asked when discussions about professional learning took place. This meant that all professional learning had a purpose and could be monitored and evaluated in the light of improving student learning outcomes.

At OLGC we felt we had a strong Multi Domain approach to teaching. We had the main ingredients of “key concepts”, “throughlines” and planning that allowed students to “take action”. However, despite these strategic directions, we still taught science separately; perhaps we were still too scared to teach science in other ways because of a lack of understanding. I say that because science was an area of the
curriculum that the staff felt most uncomfortable teaching. We decided together that we needed to address the issue.

As a leadership team we strongly believed (from staff feedback) that it was time for us as educators to rethink what science meant for our students and also what that might mean for our teachers and their practice. In so doing, we needed to consider how we could support our teachers to address their existing perception of science so that they might be better able to provide learning experiences that would assist our students to develop the skills and thinking they would need for future learning.

The big question for us as leaders was “How do we support our teachers to ensure that science teaching and learning is meaningful while they at the same time also attempt to work within an already crowded Multi Domain curriculum?” These questions challenged us as leaders but they are also at the heart of the matter that leadership groups in schools everywhere need to be willing to explore, and be challenged by, if science education is to become an important and relevant aspect of contemporary learning in our schools.

SCIENCE: SO WHAT?

So why is science an important part of student learning? Well have you ever opened a newspaper and counted how many articles are related to science? Your initial reaction may be ‘not many’. I also thought this but when I began to look more closely I was very surprised. I found that every day there were many stories which in some way related to science and that position science ideas as part of the world around us. While some stories do not initially appear to be specifically about science, on closer examination an enormous amount of science thinking is either embedded in the content of these articles or is required by the reader to be able to make sense of the information. To provide an example of my thinking, consider articles which recently outlined the collapse of a pedestrian bridge in New Delhi two weeks prior to the opening of the Commonwealth games. Those articles, as well as stating the obvious newsworthy items e.g., the number of workers injured, etc. also implicitly implied that the reader should be able to consider why the collapse happened.

Some of these articles suggested that there was a link between the weeks of heavy rain that occurred prior to the time of the collapse. So implicitly, the reader has to make sense of why heavy rainfall may have been a contributing factor to the event (collapse of the bridge). I wonder as you read my musings about these reports what ideas are now running through your mind? Are you drawing on some personal knowledge of science to help you develop a connection or make a link between the two events? Maybe you are thinking about the soil type or the type of foundations used in the bridge construction? Maybe you are considering types of building materials? Perhaps the rain pressured construction deadlines and in turn this impacted on the attention to detail undertaken in the building process. All of these possibilities are science based and demonstrate that the ideas in science need to be thought about and applied in order to be meaningful and useful.

Floods in Pakistan have also attracted much attention in the news. Once again there was the inevitable focus on loss of life and the human disaster which resulted,
but can the reader make connections between flood damage and the ongoing risks to human life which many articles suggested? Why do risks to health and well-being continue way beyond the actual event that caused the immediate devastation? Why is disease more likely to occur at these times and how does such heavy rain threaten food supplies?

For a reader to fully engage with these articles and the ideas contained within them, some understanding of science becomes important but equally, so is an understanding that science is interconnected with everyday life.

In my mind knowing and thinking about science provides a way of thinking about and engaging with the world around us. As a consequence, that means that as educators we need to support our students in developing and using this knowledge and thinking so that they can be engaged with and make sense of their world. It is that type of thinking that leads me to the view that we need to make science an important part of student learning. But what does that mean for how we approach the teaching of science?

RETHINKING SCIENCE AT OUR SCHOOL

At OLGC the leadership team shared an understanding (briefly outlined above) of science and began to discuss the classroom implications of these views in terms of science education. These discussions were strongly supported by the professional learning experiences that some members of leadership had undertaken. The Catholic Education Office Melbourne (CEOM) in partnership with Monash University had developed a professional learning program entitled Science Teaching and Learning (STaL), and this program became one of the main sources of inspiration and direction for rethinking science at our school.

Over a six year period OLGC committed an enormous amount of time and staff participation to the STaL program. Partly because the feedback from the first group of staff who participated indicated they felt more confident about their understanding of science concepts, and partly because of the way in which they discussed their experiences of STaL with other staff and the leadership team. As a consequence, the leadership team could not help but see the value in ensuring that all staff experience professional learning in the way it was structured and organised through STaL. The need was clear, the response was obvious.

The school’s leadership made sure that the professional learning budget included sending staff to the STaL program each year. Science as part of a multi domain curriculum now had its own budget. Not just for equipment but ensuring it was integrated appropriately into our multi domain approach. It was obvious that the staff were embracing professional learning in science. Not attending the STaL program personally actually increased my ability to lead. This might sound strange but it made me listen more to staff, act on their feedback, and ensure appropriate support was given to them. The result was a committed staff that asked, “when is it my turn to attend STaL?” They wanted to be part of what was occurring in science. This was a total change from our earlier approach when we identified science as a point of concern in our curriculum.
From that time on, as a leadership team, we began to acknowledge the importance and benefit of reflection on our practice. Reflection was identified as not only important in the area of science but across the whole curriculum. This was also evident in the Enhancing a Performance and Development project in which we were also involved. As part of that project we provided opportunities for staff to receive feedback and then have time to reflect on that feedback and their practice. The leadership team felt this was important to individuals in helping them to develop their own practice.

Our thinking about science was shifting and as a consequence the school worked to promote more science teaching which in turn raised the profile of science in the school. More time was devoted to teaching science, more than ever teachers were talking about experiments and science activities; things were happening. Building on this, staff were encouraged to collaborate and to write about their experiences (see, Smith, 2007). That book captured their reflections about their science teaching experiences and helped to create even more interest and commitment to enhancing science teaching and learning at OLGC. Together, these steps were important in re-shaping how we approached our professional practice. Yet we were still not satisfied with how we were planning and teaching science. It still appeared to us as though it was a separate part of the teaching in each classroom. The content was not linked or intergraded into unit work and the teachers often only thought about science as experiments and wow activities (not dissimilar to that which Appleton (2002) described as ‘activities that work’).

We had to extend our journey further. We saw the need to take a further step into thinking about how to build on the learning that emerged from the writing experience. Our expectations for professional learning were continually realized as our learning experiences continued to impact our work in positive ways.

**SCIENTIFIC LITERACY: WHAT DOES IT MEAN?**

A new term began to emerge in our discussions ‘scientific literacy’ but we had no idea what it meant or if it had any place in our school. We were familiar with similar terms being bandied about by our politicians about proficiency in literacy, mathematical literacy and so on, but there was less talk about students being scientifically literate so it was a new idea to us – one that initially seemed another piece of academic jargon.

We were familiar with the notion that someone who is mathematically literate can participate in their world mathematically, that is they could walk into a shop with $10 and know how many items they could buy. Or they would know how long they needed to wait before the next train arrived at the station. Being mathematically literate supports being an independent person in the world and links with the idea of being an independent learner - someone who can take control of their own learning.

As a leadership team, we thought if that was the case for mathematics then perhaps we should consider similar ways of thinking in terms of science - especially knowing that our students encountered so much science in their everyday world. We wanted the same skills and independence to be developed for our students in science. We wanted
our students to become scientifically literate. We wanted to see our students choose to read about science in their reading hour and to be able to discuss with their fellow classmates their views about the issues they were reading. We wanted our students to be reading and willing to identify local and international science issues and incorporate them into the “So what?” of their inquiry during their multi domain units.

With all of this in mind and the financial support and backing from the CEOM we decided that the first step for us all as educators was to rethink our perceptions of science. The leadership team felt that this meant we had to encourage teachers to move away from the more traditional primary school ways of thinking about and teaching science. We needed to change the prevailing perception that classroom science was all about experiments. We needed to start finding ways to link with the science that was all around us in our everyday world.

The world our students live in is more than just their local community, they have access to information from everywhere and that information is accessible from a variety of sources and available at almost any time. The world had become a global community. As educators we could see that accessing information was easy but we wondered whether our teaching helped or hindered students in determining the accuracy and validity of that information. How would they be able to decide how to use information to assist their decision making? What thinking, knowledge, communication, personal and interpersonal skills did they need to function in that way?

At both a leadership and staff level we began to see that perhaps as a school we were not developing the necessary skills as effectively as we could and that perhaps one way of doing that better was to utilise more meaningful contexts for learning.

CREATING THE CONDITIONS FOR CHANGE

The leadership team believed that the biggest influence on our students was teachers so we decided to concentrate more time, finances and opportunities in finding ways to support the development of teachers’ practice in our own school context. We could see the need to work on raising awareness of our own practice and assist and find alternative ways to think about and attend to our teaching.

We employed a critical friend to support us in our planning meetings and to work with teams of teachers in asking questions and challenging our thinking about our planning and our practice. The critical friend was able to view multi domain planning and suggest/discuss with staff how to incorporate scientific literacy into their units of work. This support helped provide staff with the confidence they needed to own their professional decisions and to approach scientific literacy in new and innovative ways.

We provided time for teachers to talk and work together to share ideas and strategies and reflect on their work. We gave our teachers permission to take risks with their teaching and learning ideas in the classroom and we trusted them to make decisions that would be appropriate for their students’ learning in their classroom contexts. What we very quickly started to see then was teachers engaged in professional discussions. Approaches to unit planning also started to change and we began to hear the term scientific literacy used more widely across the school.
WHAT IMPACT HAS SCIENTIFIC LITERACY HAD ON STAFF AND STUDENTS?

When you are so heavily involved in a project or new learning it can become easy to overlook growth and achievement. This seems to be particularly so when it comes to schools and change. Teachers are often harsh critics of themselves and each other. It is often not until they map their success or have seen their efforts highlighted and valued by others that they genuinely see and feel a sense of achievement – and that approach seems to pervade all levels of educational systems and bureaucracies.

Indicators of success are formulated in many ways. Some forms are helpful and others perhaps not so - especially noticeable when cause and effect is seen as a simple mathematical exercise (teacher says + student does = measureable outcome). The reality of teaching and learning is that it is a complex process with sometimes outcomes that are both expected and unexpected, but embedded in the day to day happenings of the classroom in ways that too easily go unnoticed. The pedagogical expertise that is brought to bear in helping students learn for understanding is evidence of knowledge, skill and expertise that often goes unrecognized and under-valued (Loughran, 2010).

One of the strongest indicators of success for us as a leadership team occurred at staff meeting in early 2010 when Professor John Loughran from Monash University asked to attend a staff meeting. We were discussing what we had been doing, and as was typical for us, we shared our ideas and concerns about our practice. John said something to the effect that, “The conversation currently taking place here does not happen in many schools and I don’t think was happening in this school 3 years ago.” His statement was telling for me because it was at that moment that I realised that everything we had invested so much time in as leaders was now bearing fruit; this was a measure of success that we could quite easily have overlooked. The type of recognition inherent in that experience is the type of thing that develops self-belief so crucial to ongoing success. It confirmed to us as leaders that we had been working towards something that was leading to positive change not just in terms of teacher thinking but more so, in the culture of learning at our school.

SCIENTIFIC LITERACY: WHERE ARE WE NOW?

Scientific literacy is defined in PISA as:

… an individual’s scientific knowledge and use of that knowledge to identify questions, to acquire new knowledge, to explain scientific phenomena, and to draw evidence-based conclusions about science-related issues, understanding of the characteristic features of science as a form of human knowledge and enquiry, awareness of how science and technology shape our material, intellectual, and cultural environments, and willingness to engage in science-related issues, and with the issues of science, as a reflective citizen. (OECD, 2006, p. 12)

There are many definitions of scientific literacy out there but the reason for choosing the one noted above is mainly for the last four words “as a reflective citizen”. At OLGC these are the words we have come to value and these are the words which
drive our practice. These words emphasise for us the importance of wanting our students to be engaged in the science that is happening around them on a daily basis.

Currently the CEOM has released their ‘Sacred Landscape’ (CEOM, 2009) document which outlines their vision for contemporary learning. A component of their schema is engaging the learner in the contemporary world. What better way to do this than through scientific literacy? As discussed earlier in this chapter, scientific issues are part of our everyday world and if the learner is to “take action that matters” then what better way to achieve this than through a serious focus on developing scientific literacy. The journey to achieve that at OLGC has been challenging, not always easy but without doubt, exceptionally rewarding and that has been for a number of reasons around the types of things we have questioned and taken seriously in our reconsiderations of science teaching and learning.

Should science be a part of the primary school curriculum? Should experiments be a component of that science curriculum? Should schools have science rooms/areas? The simple answer is yes. Science/science spaces in schools should be such that students are able to be immersed in different forms of thinking and learning about the world around them. It should be that children read about scientific events and investigate scientific ideas and use current technology to further develop their understandings, and should be able to do so in comfortable chairs not necessarily behind a bench with a goose neck tap and deep sink. Should science be held every Thursday afternoon between 2.00 pm and 3.30 pm? The simple answer no. Science should be part of a multi domain approach that truly supports curriculum development. In that way, scientific literacy can be a goal that will have real impact on student’s learning. That would be a good measure of success.

Being a part of the Scientific Literacy project at OLGC has taught me much about leadership and the conditions required to support school based change as well as everything I have learnt about scientific literacy. I am firmly of the view that in undertaking any new project it is important for it to be supported by the school’s leaders. That support means there needs to be a clear vision, a noticing (in the ways described by Mason, 2002) of the needs of teachers as they try new things and develop alternative approaches to practice. Above all it requires trust in teachers as the prime movers in enhancing learning, that is, a trust in the capacity of teachers as professionals. I have seen it work that way, the chapters in this book illustrate it for others to see and understand.

REFERENCES


Brian Grace was the Deputy Principal and then Acting Principal at OLGC throughout the Scientific Literacy Project. He has recently accepted an appointment at another school as Principal.