Developing a pedagogy to support science for health literacy

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Introduction

This foreword builds on the premise that many health issues are unavoidably socio-scientific issues impacting on the social and economic wellbeing of communities. The implication of this is that adolescent education should facilitate the development of lifelong learning skills that will support informed decision making relating to health at an individual, family and community level. To achieve this we must draw on behaviour change theories and transactional and transformative learning models which result in health-related changes in students' understanding and beliefs about themselves and their social context, and long-lasting lifestyle changes (Mezirow, 2000, EU, 2009). This requires a pedagogical approach that develops an understanding of the science underpinning common health issues, social issues underpinning the determinants of health, and the skills to enable students to access and interpret information to make informed judgements regarding health and wellbeing over the life-course. The delivery of such education programmes is undoubtedly cross-curricula in nature, linking strongly into health education, physical education, science, humanities and

technology curricula. When we consider the potential impact of the determinants of health on personal and societal well-being, the links into mathematics and economics curricula cannot be ignored. However in this paper we focus on the key curricula areas of science and health. Despite widespread acceptance that health matters form a natural part of these curricula, there currently exists a clear disconnect between scientific literacy and health literacy; indeed, these two concepts tend to reside within two separate bodies of literature. We unpack the concepts of scientific literacy and health literacy and suggest components of a bridging pedagogy which supports 'science for health literacy'. In particular, we will focus on the significant challenge offered to teachers in the development of learning opportunities that allow students to explore the complex issues underpinning the global non-communicable disease (NCD) epidemic, an issue of significant and growing concern that we believe to be under-represented and poorly linked in school curricula. We view health literacy as a precondition for education for sustainable development and citizenship and propose that health literacy cannot be isolated from science literacy.

The global non-communicable disease epidemic

Non-communicable diseases (NCD), primarily cardiovascular disease, diabetes, chronic lung disease and cancer, cause 63% of deaths globally. Prevention of 80% of these deaths is possible through changes to behaviours throughout the life-course surrounding the four major causative risk factors of tobacco use, unhealthy diet, physical inactivity and harmful use of alcohol (WHO, 2008). The increasing burden of NCDs is creating a significant economic and social load on society (ibid, Beaglehole et al., 2011). Recognition of the need for international action to address the socio-economic impact of this growing epidemic led to the United Nations Global Summit on Non-communicable Disease Prevention and Control in

September 2011. The gravity of the issue is highlighted by the fact that the only previous health issue that has warranted a meeting of the UN General Assembly was AIDS (UN, 2011). Addressing the NCD epidemic is complex. While the four major causative risk factors are agreed upon, these cannot be isolated from the complex and multiple socio-economic and environmental determinants of health and wellbeing (Dahlgren & Whitehead, 2007) and the growing knowledge of the impact of early life environment on NCD risk in later life. It is now well established that early life development (pre-natal onward) is a critical time for setting trajectories for health and wellbeing throughout the life-course (Gluckman and Hanson, 2006). As a consequence of developmental plasticity, the potential exists for the early life environment to permanently modify post-natal phenotype and therefore alter vulnerability to disease risk in later life (Gluckman et al., 2011). This is known to extend across a full range of maternal environments during pregnancy, from under-nourishment through to obesogenic, therefore it is relevant for all children from both the developing and developed world (Gluckman et al. 2007). Evidence suggests that epigenetic mechanisms partially account for this pattern of effects with some indications of transmission of these effects into subsequent generations (Godfrey et al. 2010). The compulsory education sector can potentially play a significant role in supporting efforts to reduce NCD risk though education that facilitates adolescents to explore the underpinning science and social issues. So while many teachers of science are utilizing aspects of NCD as contexts for the development of understanding of key science concepts, and many health programmes in schools are addressing aspects of this issue related to healthy behaviours, the complexity of the issue calls for greater interdisciplinary interaction within schools, and between schools and the science and health sectors. There is a need to support teachers to engage in open accessible dialogue with the science and health communities, provide access to real data that students can explore, and support the development of learning resources to allow the

compulsory education sector play a role in the global efforts address the NCD burden on future generations.

The connection between scientific literacy and health literacy

The internet is the first place most students search for scientific information, and with the ever increasing volume and availability of web-based information on sites such as *Wikipedia* and discussion forums, it is vitally important that a scientifically literate citizen needs to be able to distinguish between science and pseudo-science, consider risks and benefits, and decide which sources of information to trust. There are numerous and diverse definitions of scientific literacy (for more comprehensive accounts see for example Bybee, 1997; Laugksch, 2000; Millar and Osborne, 1998; Millar, 2008). Although the proposed details vary, there is a general consensus that scientific literacy involves applying scientific understanding to real situations which call for evaluation and decision-making. The Organisation for Economic Co-operation and Development (OECD) Programme for International Student Assessment (PISA) defines scientific literacy as: *"…the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity*." (OECD, 2003:133) Achieving this literacy involves development of an understanding of the complexity of scientific issues and the nature of science itself, concepts that have emerged as central in science curricula worldwide in recent years.

The World Health Organization defines health literacy as "*the cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain good health*" (Nutbeam, 1998: 357). Nutbeam (2000) makes distinctions between three types of health literacy: basic/functional

literacy (reading and writing in relation to health), communicative/interactive literacy (cognitive, literacy and social skills to extract information, derive meaning and apply the information to changing circumstances), and critical literacy (skills to critically analyse information and use it to help control changing circumstances). Education for critical health literacy can lead to personal empowerment and autonomy in relation to health, and involves developing a 'critical consciousness' of the kind advocated by Friere (1970), supported by an individual's orientation towards social and political action. This has the potential to facilitate individual or community action which may alter the social, economic and environmental determinants of health. This orientation reflects behavioural intention rather than an attitudinal response. Ajzen and Fishbein's (1980) theory of reasoned action indicates that behaviour is a function of behavioural intentions rather than one of attitudes. Another important outcome of critical literacy is improved self-efficacy. Garcia and Mann (2003) tested several social-cognitive models for engaging people in health behaviours and found that models which included self-efficacy were better predictors of intentions to engage in positive health behaviours.

Scientific literacy is conceptually broader than health literacy in that it also connects with non-health related matters. Take for example, the question of where to site a new predator-free restricted access nature reserve for the conservation of endangered species. This would involve scientific, environmental, socioeconomic, cultural, and political components, but not necessarily an overriding health dimension. So it is possible to engage students in scientific literacy without necessarily considering health issues, but we argue that, at least from a normative post-positivist perspective, it is much more difficult, and indeed untenable, to disconnect health literacy from science. In discussing scientific literacy, Millar and Osborne (1998:25) recommend that students should develop *"...the capability to assess the reliability*

and validity of evidence, to distinguish evidence from explanations, to identify obvious gaps in evidence or reasoning, and to appraise the level of confidence to be ascribed to any claims advanced." We would contend that without this capability, students would be unable to navigate their way through health issues, and that health literacy is therefore dependant on scientific literacy. Furthermore, just as scientific literacy education should be for all students of all abilities, in addition to specialised scientific training for the minority who aspire to become scientists, we advocate a parallel approach for health literacy: it is for all young people growing up in our modern societies.

At this point adherents of scientific literacy might ask why we are making a distinction between scientific and health literacies; surely the latter is subsumed by the former. Whilst this may be a normative claim, the reality is quite different. Firstly, the two concepts lie in entirely separate bodies of literature. Health literacy definitions and documents tend to take a socio-political perspective and rarely make immediate or explicit connections with science or scientific literacy. Secondly, they assume completely separate niches and command different levels of status and attention within the school curriculum. What is currently lacking in the curriculum (and in our opinion quite tragically) is the glue that holds these two literacies together, which we are describing here as a pedagogy to support "science for health literacy", i.e. a pedagogy for the science underpinning health literacy which acts as a vehicle for making the links explicit to students and ensuring that scientifically literate adolescents also become health literate.

The difficulties teaching science for health literacy

Many health issues can be considered socio-scientific issues (SSIs) in the sense that they that they have a basis in science and a potentially large impact on society (Ratcliffe and Grace,

2003). Sadler (2004, 2011) gives thorough reviews of research and teaching about SSIs, and Lee (2011) gives a useful overview of the nature of health and the relationship between SSI education and health contexts. Engaging in substantive discussion and decision-making about SSIs requires scientific literacy, and if these issues are health-related they also require health literacy. Over the past twenty years there has been a global move to include SSIs in science curricula (e.g. HKCDC, 2007; NRC, 1996; KMK, 2004; QCA, 2004, MoE, 1993, 2007).

At first sight, one might expect health issues to lend themselves perfectly as a context for teaching teenagers about SSIs - diseases and medical conditions can fascinate or frighten people, and teenagers are often preoccupied by (and sometimes obsessed with) health matters. Furthermore, we all have first-hand experience of health issues and can relate to them accordingly. They have attracted considerable media attention in recent years with the emergence of new contagions such as avian and swine influenza, resistance severe acute respiratory syndrome (SARS), and the burgeoning growth of NCDs such as diabetes, cardiovascular and lung diseases and certain forms of cancer.

However, as Lee (2011: 2) has pointed out *"…health issues are not commonly dealt with in the SSI literature…*". So why this avoidance of health-related SSIs? Well actually there are a large number of reasons, most of which relate to the experiences, background education, and expectations of science teachers, such as:

- priority given within the curriculum and national assessment systems to acquiring knowledge and understanding of concepts, rather than time for consideration of social and ethical issues;
- some teachers' perception that social issues should not be part of the science curriculum;

- lack of teacher expertise or confidence in handling issues associated with large amounts of often incomplete information with no ‘correct’ answers;
- lack of knowledge or expertise in teaching strategies to cope with controversial issues;
- lack of teaching resources which appropriately render the latest advances in science to a level which is meaningful to school students;
- philosophical and logistical barriers in achieving potentially advantageous cross-curricular collaboration;
- concern that health issues might overtly or inadvertently relate directly to the lives of students in the class, which demands that the teacher employs additional skills of teaching about sensitive issues alongside potentially unreliable access to appropriate support services;
- the logistical and time-consuming requirement to gain written consent from all the parents/carers of students in the class.

Engaging with SSIs is complex, involving forming opinions, making decisions at personal or societal level, critical analysis of media reports (from where most of our daily information emanates), evaluating knowledge claims, consideration of values, and ethical and moral reasoning (Fowler et al., 2009), and may require some understanding of probability and risk (Levinson et al., 2011; Rolfe, 2010) or even include humanistic perspectives (dos Santos, 2007). They are inherently based on incomplete or often conflicting information and a degree of subjectivity, and are frequently topical with a transient life and have no particular right solution. These are all inexact properties which understandably unsettle many science teachers who have been trained throughout their school and university lives to deal with, and therefore teach about, hard scientific ‘facts’, and this is also what many lay people (including politicians) expect them to teach. The constraints imposed by timetabling,

compartmentalisation of subjects and organisational structures in secondary schools also makes it difficult for teachers to consider a cross-curricular approach. Hodson (2003) called for a socio-political science curriculum, training students to be both scientifically and politically literate citizens who have active critical engagement with the issues Zeidler et al., (2005:359) argued that SSI education should *"exploit the inherent pedagogical power of discourse, reasoned argumentation, explicit nature of science [NOS] considerations, emotive, developmental, cultural or epistemological connections within the issues themselves"*. We fully endorse these approaches, but many (probably most) science teachers are not adequately trained or resourced to deliver it. Teachers have to contend with the uncertain, tentative, nature of science (explored thoroughly elsewhere, e.g. Lee, 2008; Abd-El-Khalick and Lederman, 2000; McComas & Olson, 1998), and this is further compounded by requiring an additional understanding of the nature of health and the complexity of the determinants of wellbeing (Dahlgren & Whitehead, 1991). This might involve taking a holistic, integrated view of biological, cognitive, affective, behavioural and social considerations, as suggested by Engel's influential biopsychosocial model (Engel, 1977), which has been used and adapted in many psychology and medical research studies ever since (Armitage and Connor, 2000).

From the demanding breadth of knowledge and skills required of teachers to deliver the kind of curriculum described above, it is easy to see why science teachers might prefer to avoid teaching about health-related SSIs. These teaching strategies can seem alien to them and are perhaps more familiar to humanities teachers, which itself raises another problem: who teachers health education? However, the potential of these contexts for exploration of the nature and application of science is far too rich to overlook. Curricula across the world obviously vary considerably, but we briefly look at examples here from two contrasting

national settings, our own countries of England and New Zealand. In both places, the nature of science takes a central role in science curricula with the potential for core concepts relevant to understanding of health issues to be explored. The devolved nature of the New Zealand curriculum offers the challenge to schools to identify and engage in learning that is of specific relevance to their community. Indications are that proposed changes to the English Curriculum (2013) will also lead to this level of community autonomy. In England, health education is mostly taught within a non-statutory subject called Personal, Social, Health and Economic Education (PSHE) for Years 1-11 / Grades K-10 and is usually taught by non-science teachers, so the underpinning science is under-represented. This may give outsiders the false impression that health science literacy is alive and well. In New Zealand Health and Physical Education are combined as one subject in the curriculum (compulsory from Years 1-10 / Grades K-9, commonly included Year 11-13 / Grades 10-12), taught in the most part by Physical Education specialists who have training in health, but not necessarily science. Connection between the health and science programmes in schools is not commonly well developed. A strong emphasis in the New Zealand Curriculum on key competencies that students need to *"live, learn, work and contribute as active members of their community"* (MoE 2007:12). These competencies support the development of relevant key behaviours and attitudes such as critical decision making, resilience, engagement with society and an understanding of self.

A pedagogy supporting science for health literacy

We outline below an on-going science-based health education programme focussing on NCDs which is operating in Auckland, New Zealand through *LENScience* (established 2006) and in Southampton, England through *LifeLab* (established 2007). The project supports the communication and translation of science relating to NCD risk, raising awareness about how

students' lifestyle choices, in particular those concerning nutrition, can impact on their future health and the health of their future children. Programmes operate both within the context of participant schools, through e-learning, and on-site within university/hospital settings. Core to all these programmes is the ability of students and teachers to access stories of science, health, clinicians and scientists relating to the development of understanding of socio-scientific factors affecting NCD risk. Access to and interaction with scientists and real scientific and health data allows students to enter into the culture of science and engage actively with the science and health communities. Programmes encourage teachers to use stories of science and student-centred investigations to explore issues of health and wellbeing, make community action initiatives to take actions relating to NCD risk prevention and community events to communicate their learning. E-learning activities that bring students from multiple schools together allow interactions that support understanding of the impact of NCD risk on communities beyond that of the student. The most interactive of these programmes brings students face to face with specialist science educators and scientists in classrooms within the university-hospital setting, Here they explore the scientific data, carry out hands-on practical activities, using equipment which is generally unavailable in schools and experience small group discussions with scientists.

We present below some key pedagogical approaches underpinning the science-science education-school partnership programmes designed by experienced science educators working within scientific institutions which have shown signs of success in promoting science for health literacy.

1. <u>Students' background knowledge, attitudes and behaviour</u>

   We take a social constructivist perspective of learning by beginning with an understanding of the students' cultural setting and their cognitive, attitudinal and behavioural responses to health issues, with a view to providing a supportive learning

environment in which we can challenging their epistemological orientations through cognitive dissonance. The setting of programmes is within a context of relevance to the students, utilising both local and international issues to demonstrate the cultural connectedness of NCDs to communities. A contextual approach such as this can motivate students by engaging them in real topics, which have relevance and meaning on an individual level, or which have an impact on their local community (Brophy, 1999; Kwiek *et al*., 2007; Rivet and Krajcik, 2008)

2. Transactional and transformative learning

Improving knowledge and raising awareness about health issues is itself inadequate. The desired outcome for science and health literacy is action resulting from informed decision making that will lead to improved health, social and economic well-being. Constructivist interventions harmonize well with transactional and transformative learning (Mezirow, 2004). A transactional model engages all stakeholders (scientists, teachers, students, families) in interactions which have the potential to challenge perceptions and lead to attitudinal and behavioural transformation. Importantly, this model emphasises the value of the interactions to all stakeholders, acknowledging the importance of scientists and the public learning from each other and the potential that this presents for the shared construction of possible futures (EU, 2009).

3. A biopsychosocial model approach

The multifaceted nature of health issues relating to NCDs requires them to be viewed from a biopsychosocial perspective (Engel, 1977; Lyons and Chamberlain, 2006; Lee 2011), bringing together underlying scientific, socio-cultural, environmental and psychological determinants. The key approach here is to strike the right balance

between the science and non-science components. Although science concepts are often overlooked in health education, Lee (2011) stresses that the reverse can also be true, i.e. that the non-science aspects are often not taken into account, and poses the example of what a lay person is to make of first-hand experience of people who chain-smoke with no apparent ill-effects. The science alone, indicating a causal relationship between smoking and lung cancer will not suffice as an explanation, and may even be challenged and contested.

4. Risk and probability

One of the challenges in addressing health related SSIs is exploration of understanding of risk and uncertainty. The teaching of risk and probability in relation to health plays an important role, although risk itself is challenging to teach as it is also contextualised, incorporates mathematics and statistics and consists of epistemic and non-epistemic values (Levinson et al, 2011), and as Lee (2011) indicates, risks calculated scientifically are also sometimes distrusted as they don't seem to relate to day-to-day experiences.

5. Using science stories and accessing scientific data

The use of science stories is employed to enable students to access the people and issues of the context of Developmental Origins of Health and Disease (DOHaD) through time. For example the story of the Hertfordshire Study (Barker et al. 1989) in which David Barker's team uncovered the birth records of 16,000 men and women born in Hertfordshire between 1911 and 1930 and traced these people to find out about their health in adulthood allows students to enter into the journey which has led to the Barker Hypothesis and subsequently inspired work which has shown that NCD

risk is in part determined by the environment that we experience in the womb (Gluckman & Hanson, 2006). Students explore how the uncovering of the story of these people led to the posing of questions which are answered in part through the story of the Dutch Hunger Winter (Painter et al. 2006). From here students explore stories of the work of current scientists such as Gluckman, Hanson, Sloboda, Vickers and Godfrey which allows them to see how science knowledge develops over time, yet constantly uncovers further questions. Science stories allow students to enter into the culture of science and explore the nature of science (Solomon, 2002). Issues of ethics, decision making and the timing of communication of science knowledge to society (when it is still uncertain) can be explored as the stories unfold. Key to the telling of these science stories is the reimaging of scientific data to enable students from age 11 – 18 to access and explore the data in an age-appropriate setting. The ability of science educator and scientist to collaborate in the development of learning resources to enable access to these stories and data is essential (Bay et al *in press*).

6. Structured decision-making discussions

Small group decision-making discussions about SSIs, using a structured framework for guidance serves a very useful way of sharing and listening to a range of viewpoints, and research has shown that it helps students reflect on and modify their views. With a careful balance of structured guidance and freedom to state one's points of view with agreed ground rules, it is possible to engage students in productive decision-making discussions about SSIs within the space of a couple of lessons in a normal classroom setting (Grace, 2009, France et al 2011). An appropriate framework endeavours to incorporate metacognitive strategies such as reflective thinking to integrate multiple perspectives (e.g. Zeidler *et al*, 2002), moral perspectives (e.g. Bell & Lederman, 2003; Sadler & Zeidler,

2004), integration of personal value identification, knowledge acquisition, and argumentation (e.g. Lee, 2007), emotive and intuitive reasoning (Sadler and Zeidler, 2004), and challenging students with opposing viewpoints to clarify their help thoughts (Simonneaux, 2001).

7. Professional development programmes for science teachers

Access to programmes that allow teachers to engage with and explore the science underpinning SSIs such as the complexity of the global NCD epidemic is provided to support effective implementation of programmes into schools. The rapid development of science knowledge related to health related SSIs means that professional development and access to appropriate summaries of scientific evidence is essential for all teachers. This is accompanied by professional development that explores the pedagogical basis of the suggested student programmes and supports teaching teams to adapt these for use in their community and looks at issues related to approaches to sensitive health issues, ethics, decision making and behaviour change. The approach follows recommendations by Hanley *et al.*(2008) that flexibility in implementing professional development programmes contributes to its success. This aims to prepare science teachers to work with their students both at school and, during e-learning events and for those with access, the university-hospital classroom visit. We have found it creates more knowledgeable and skilled teachers, but most importantly it instils confidence and self-efficacy which is needed to ensure sustained motivation within science departments and supports the school-university partnership approach to the delivery of the teaching and learning package.

8. Accessing and interacting with the science and health communities

The *LENScience-LifeLab* programmes (Bay & Mora, 2008-2011; Woods-Townsend, 2011) are based on school-university partnerships that integrate school-based e.g. Bay & Mora, 2009, 2010 and out-of-school or synchronous national e-learning events e.g. Bay, Denny & Sloboda, 2010, Bay, Mora & Cutfield 2011. The e-learning and out of school events offer unique settings upon which the classroom teacher can build. Evidence from research shows that the university-hospital classroom setting allows students to bridge the cultural divide between scientists and the community (France & Bay, 2010). The UK government inspectors recently reported that *"Learning outside the classroom was most successful when it was an integral element of long-term curriculum planning and closely linked to classroom activities."* (Ofsted, 2010).

On-going developments

Sustained health-related behavioural changes take a long time to measure, and *LENScience* and *LifeLab* continue to track past and present students. Early signs of modified attitudes and lifestyles are evident in data collected in both New Zealand and the United Kingdom to date. These data suggest that the programmes are having a sustained effect on perceptions of the relationship between diet in adolescence and future health of the individual and their potential offspring. They also indicate that the programmes are effecting change in understanding of the relationship between the nutritional environment during pregnancy and health in later life. Interview data suggests that the programmes offer the potential to support the role of students as change agents in their families. Full publication of these data is expected in 2012.

In this article we have stressed the prominence that science needs to play if we are to establish a generation of health literate citizens, capable of engaging in critical thinking and decision making resulting in transformative actions relating to health at an individual, family and community level. We have offered the NCD epidemic as a health related socio-scientific

issue of global relevance which could be explored in all schools. We have provided examples of pedagogical strategies successfully employed to deliver science for health literacy in this context. The examples come from a project being implemented in settings at opposite ends of the world, and we hope they will inspire other science and health educators to develop teaching programmes appropriate to their own contextual settings.

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